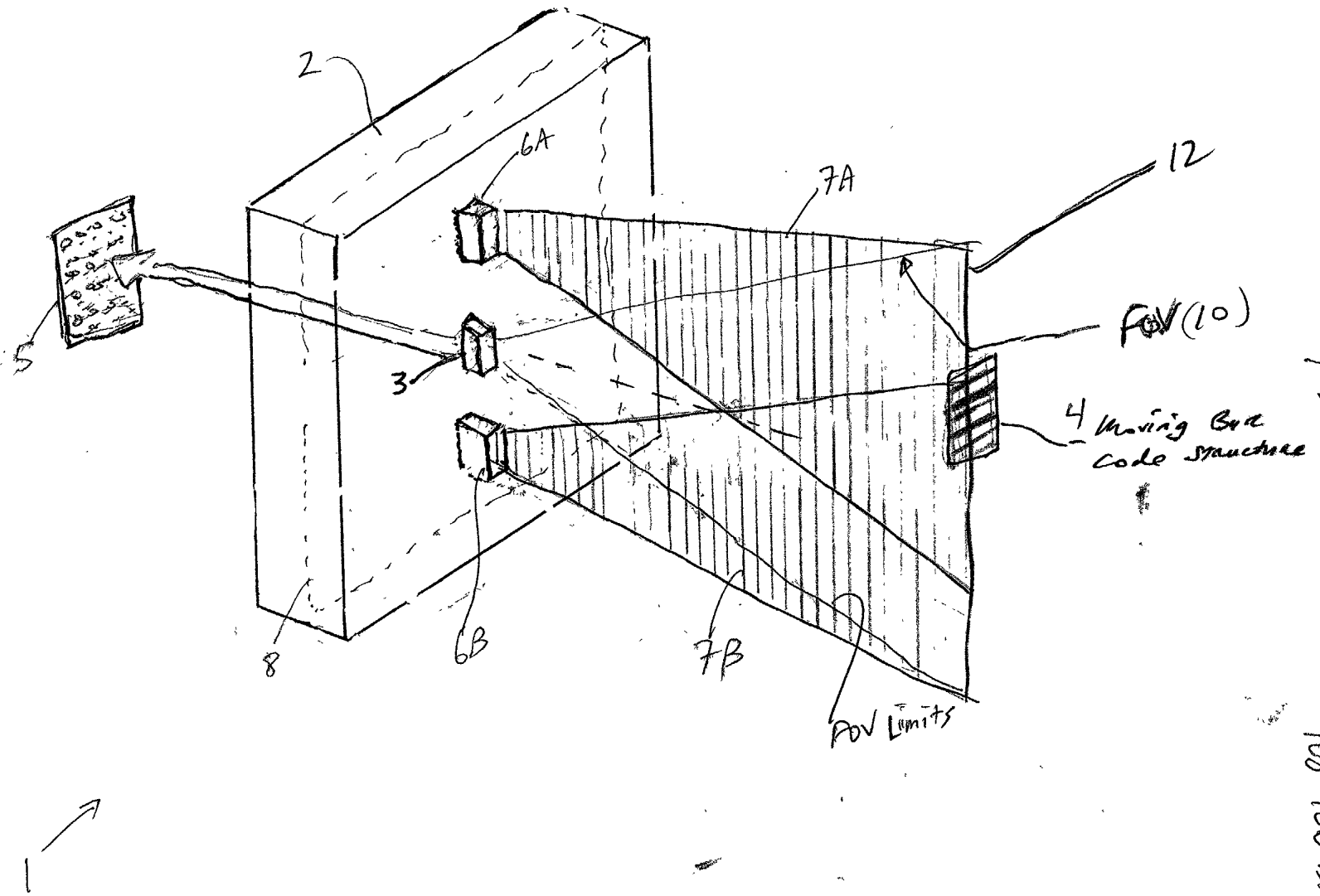

FIG. 1A

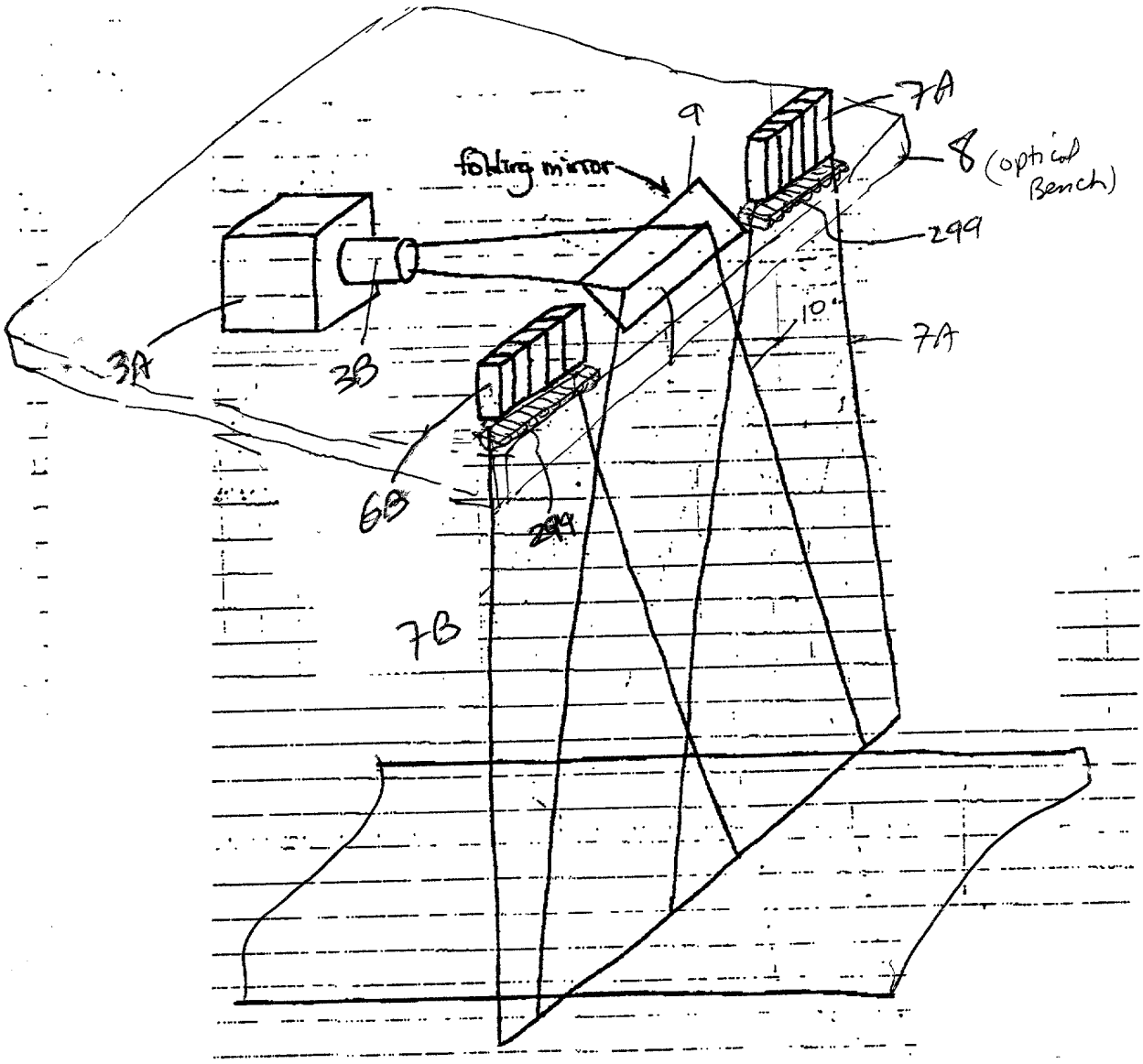

FIG. 1B1

1A

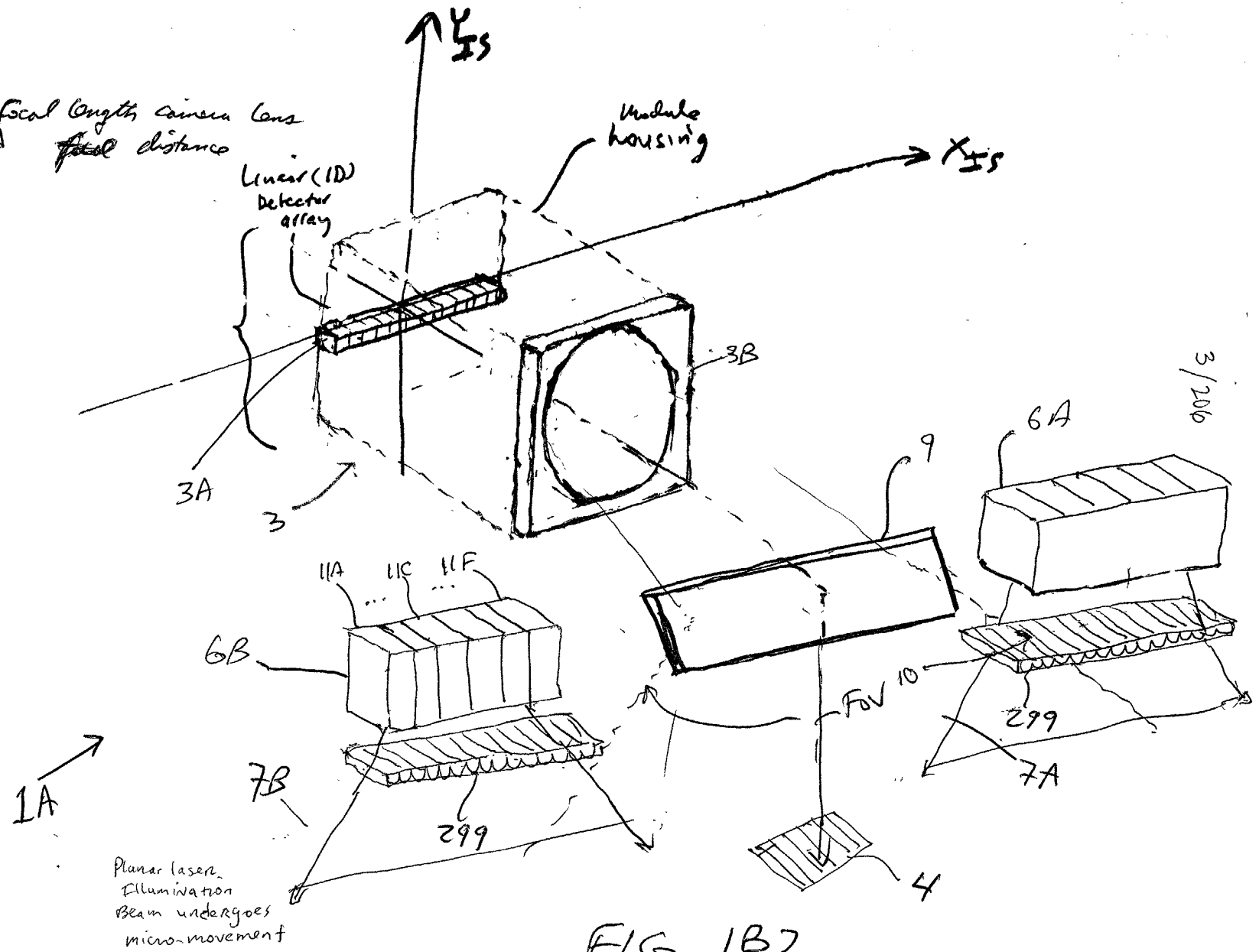
(1) Fixed focal length camera lens
(2) Fixed focal distance
Linear (1D) detector array
Module housing
3A
3
3B
9
6A
6B
11A
11C
11F
FoV
10
299
299
7A
7B
1A
4
Planar laser illumination beam undergoes micro-movement

FIG. 1B2

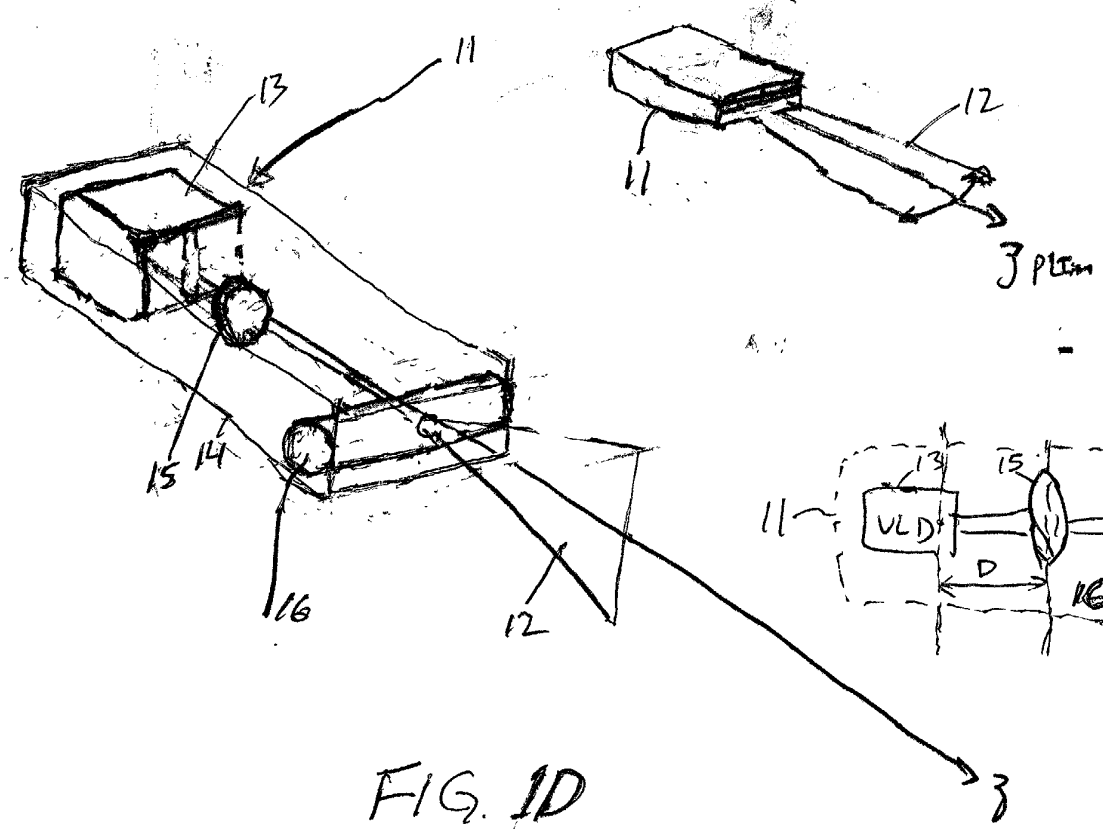

FIG. 1D

FIG. 1C

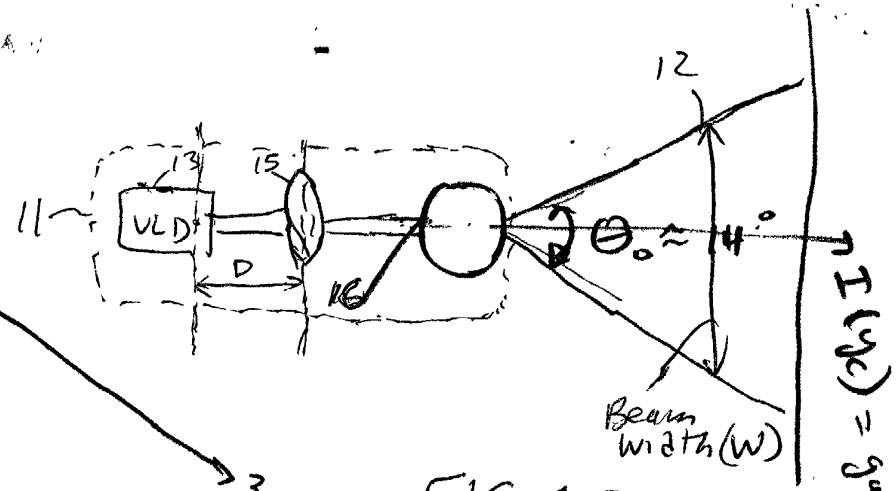

FIG. 1E1

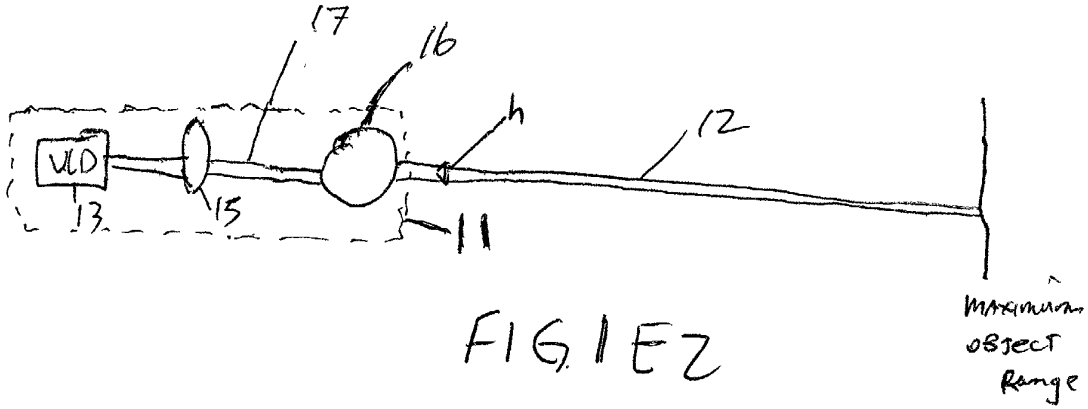

FIG. 1E2

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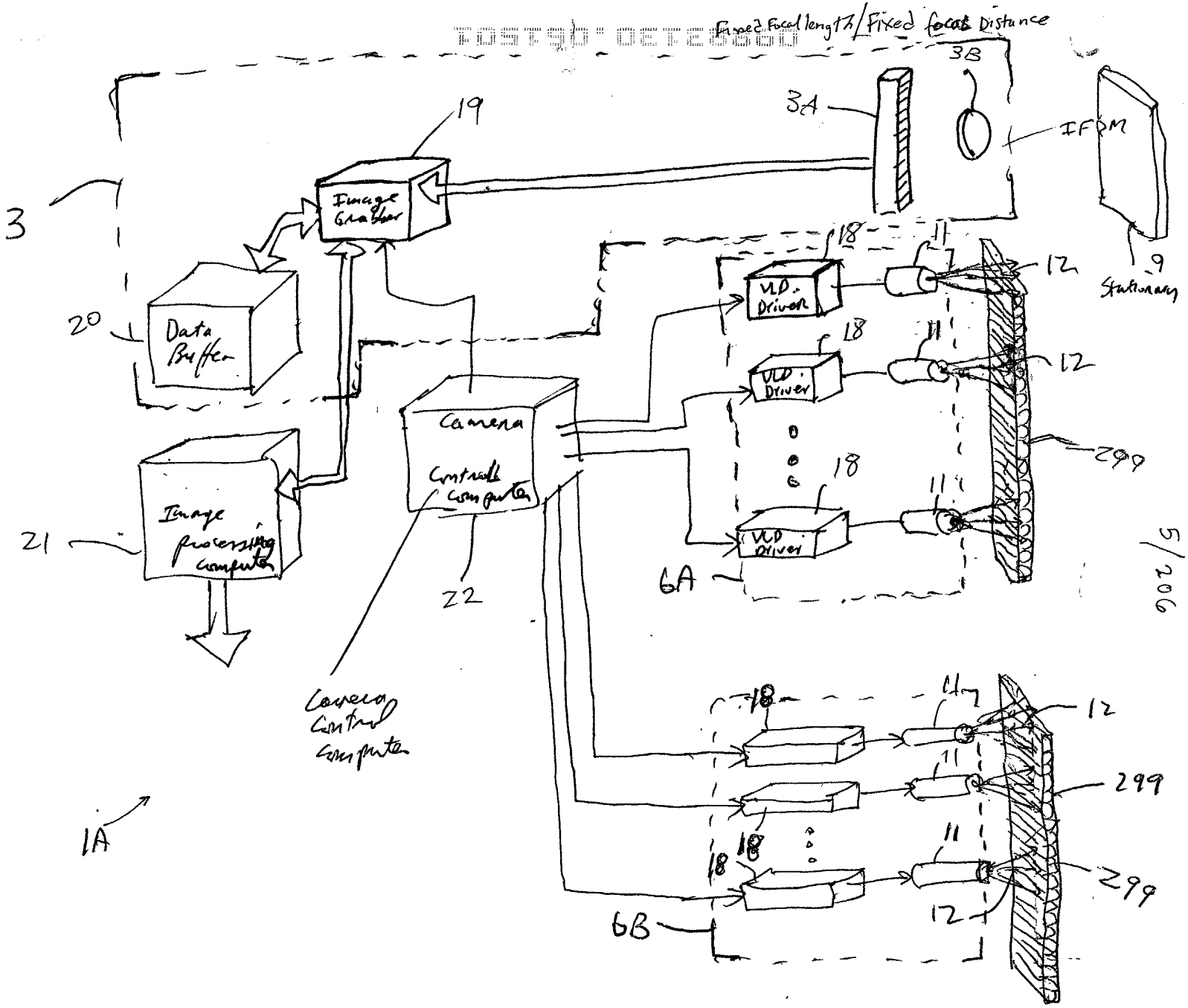
Fixed Focal length/Fixed focal Distance
3B
3A
IFOM
19
3
Image Grabber
9
Stationary
18
12
VLD Driver
20
Data Buffer
18
12
VLD Driver
Camera
Controller Computer
299
18
Image processing computer
21
VLD Driver
22
6A
5/206
Camera Control Computer
18
12
299
18
18
18
299
12
6B
1A

FIG. 1F

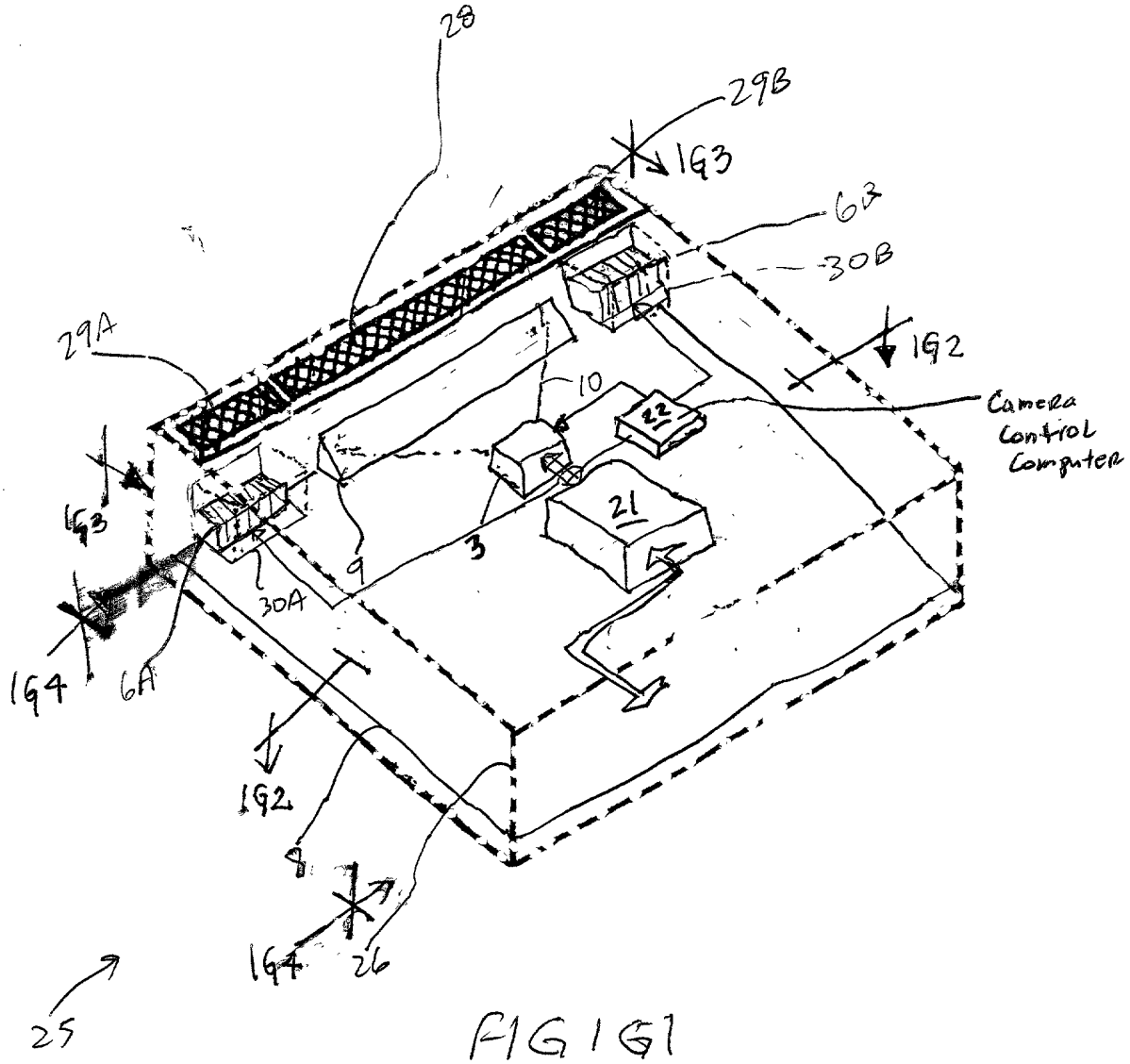
28
29B
IG3
6B
30B
IG2
29A
10
22
Camera Control Computer
IG3
21
3
9
30A
IG4
6A
IG2
8
IG4
26
25

FIG 1G1

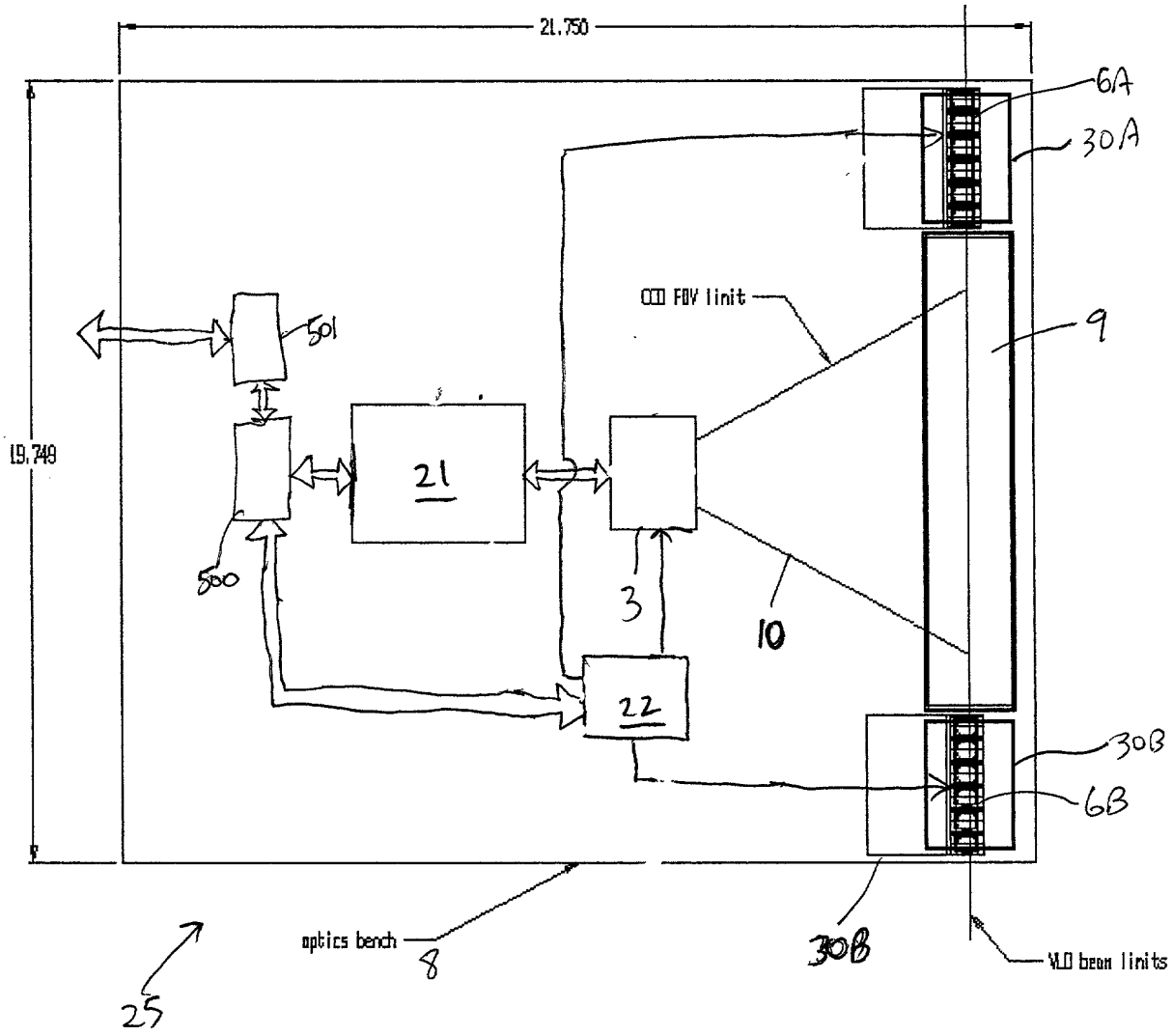
21.750
19.749
6A
30A
CCD FOV limit
9
501
21
500
3
10
22
30B
6B
optics bench
8
30B
VLD beam limits
25

FIG. 1G2

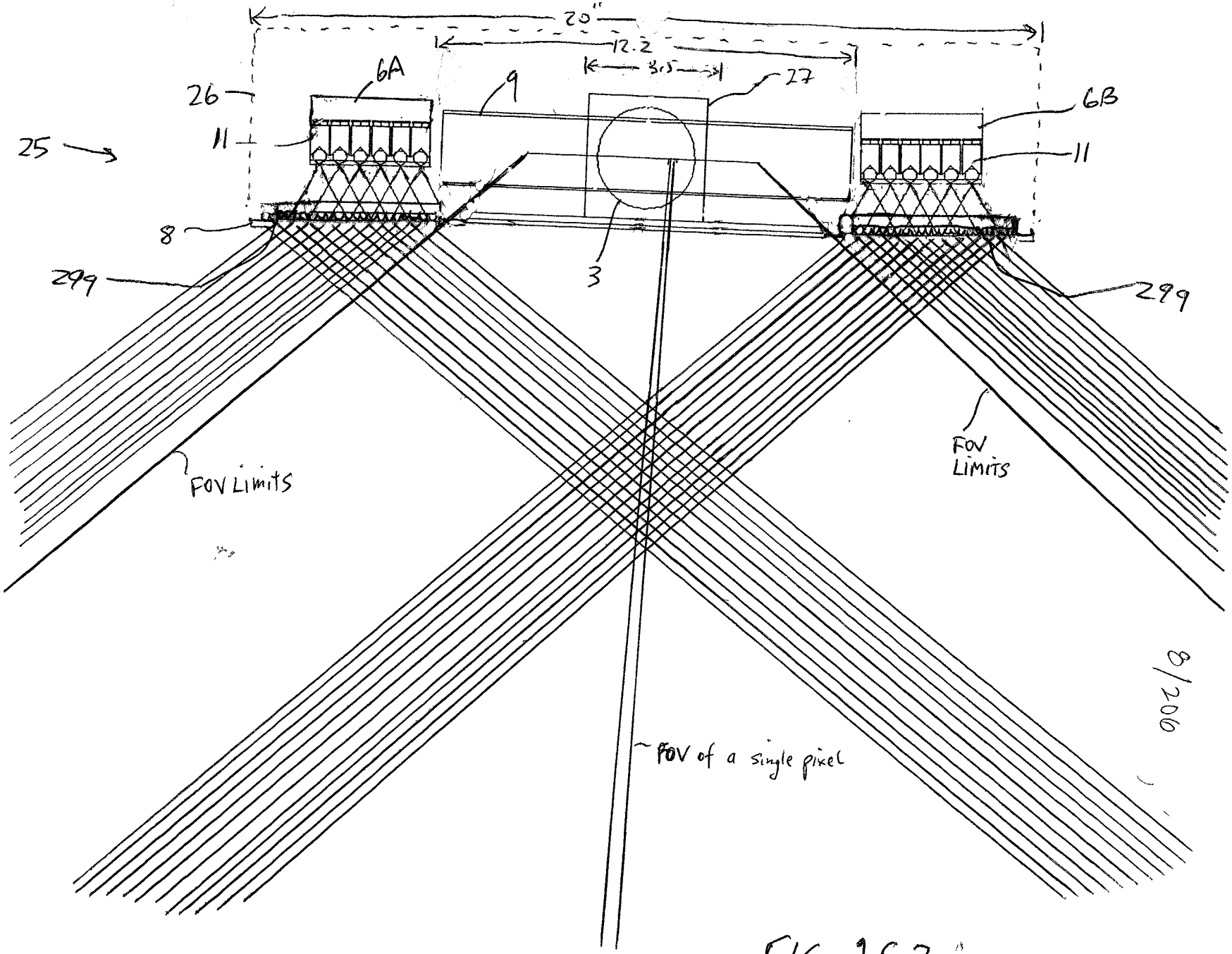
20"
12.2
3.5
26
6A
9
27
6B
25
11
11
8
299
3
299
FOV LIMITS
FOV LIMITS
FOV of a single pixel

FIG 1G3

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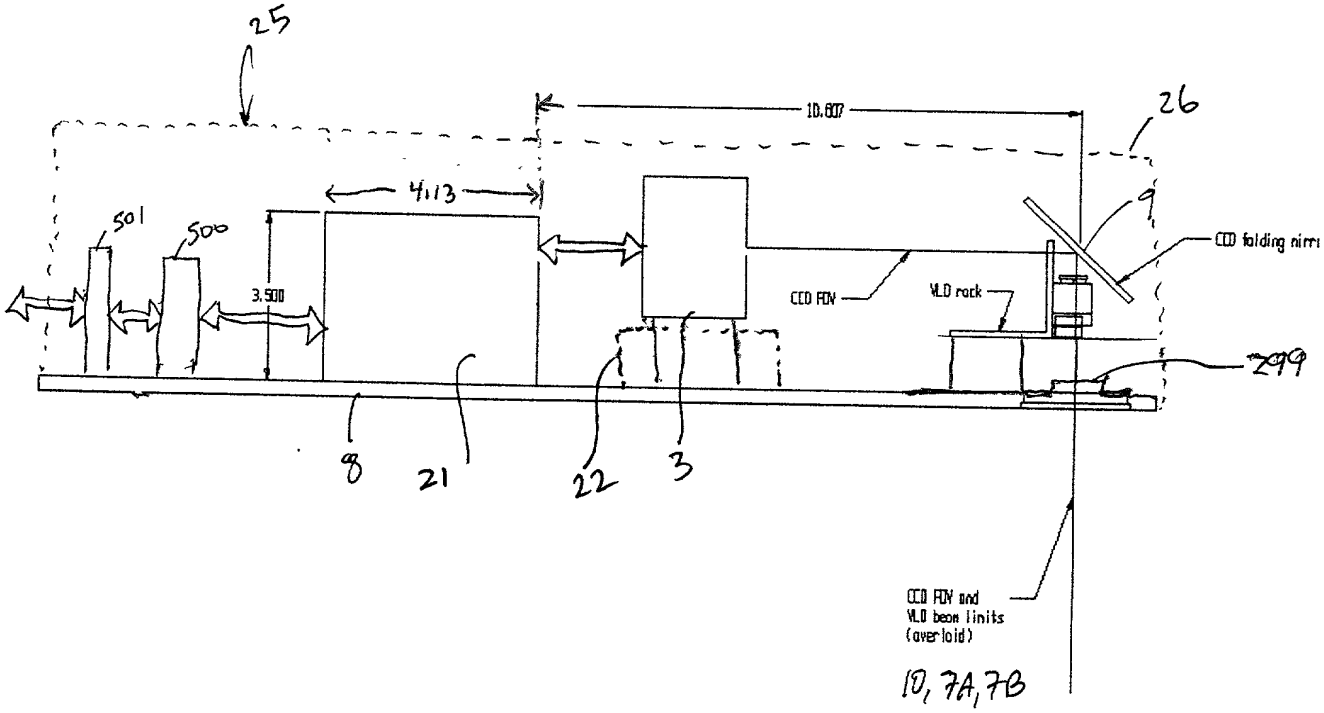
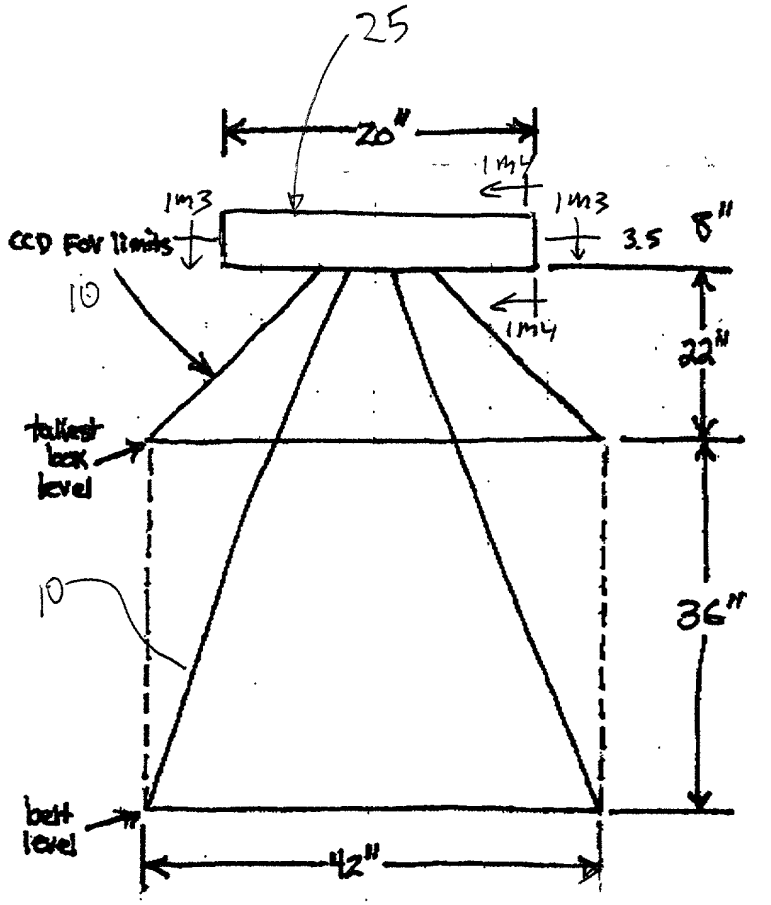

25
10.607
26
4.113
501
500
3.500
CCD FOV
VLD rack
CCD folding mirr
299
8
21
22
3
CCD FOV and
VLD beam limits
(overlaid)
10, 7A, 7B

FIG. 164



* Fixed Field of Field

FIG. 165

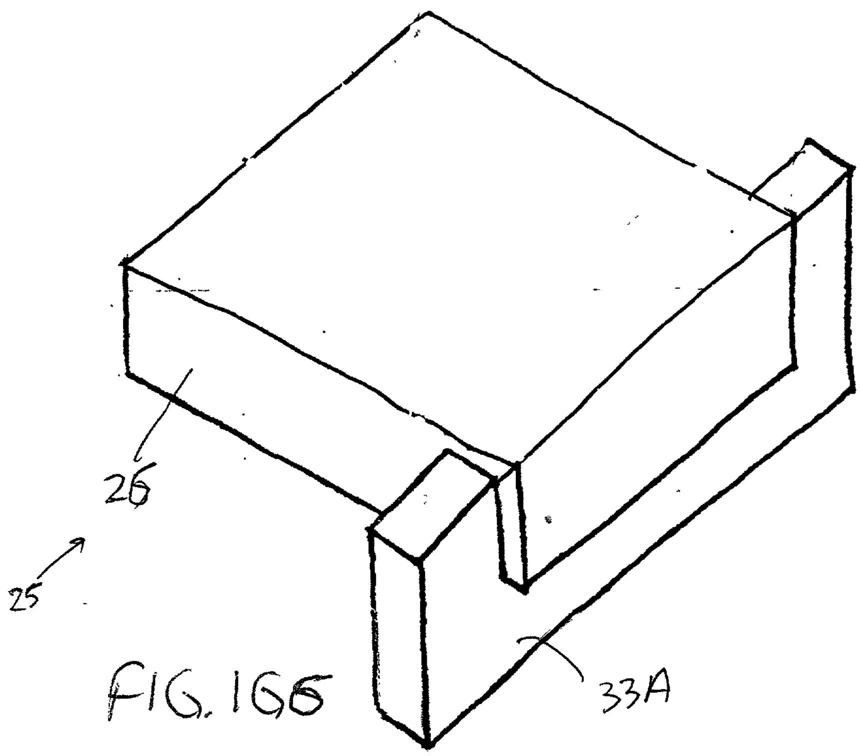


FIG. 166

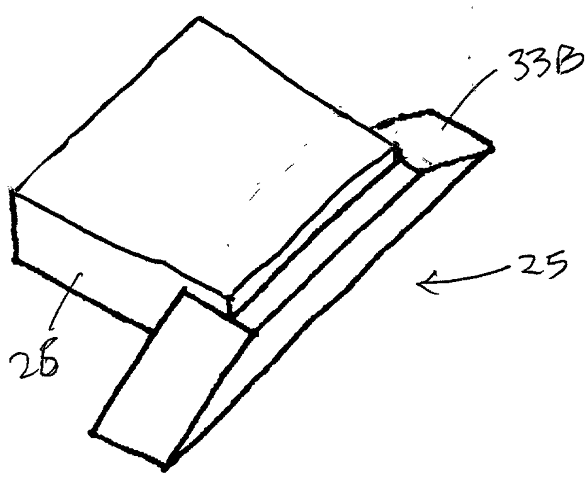


FIG. 167

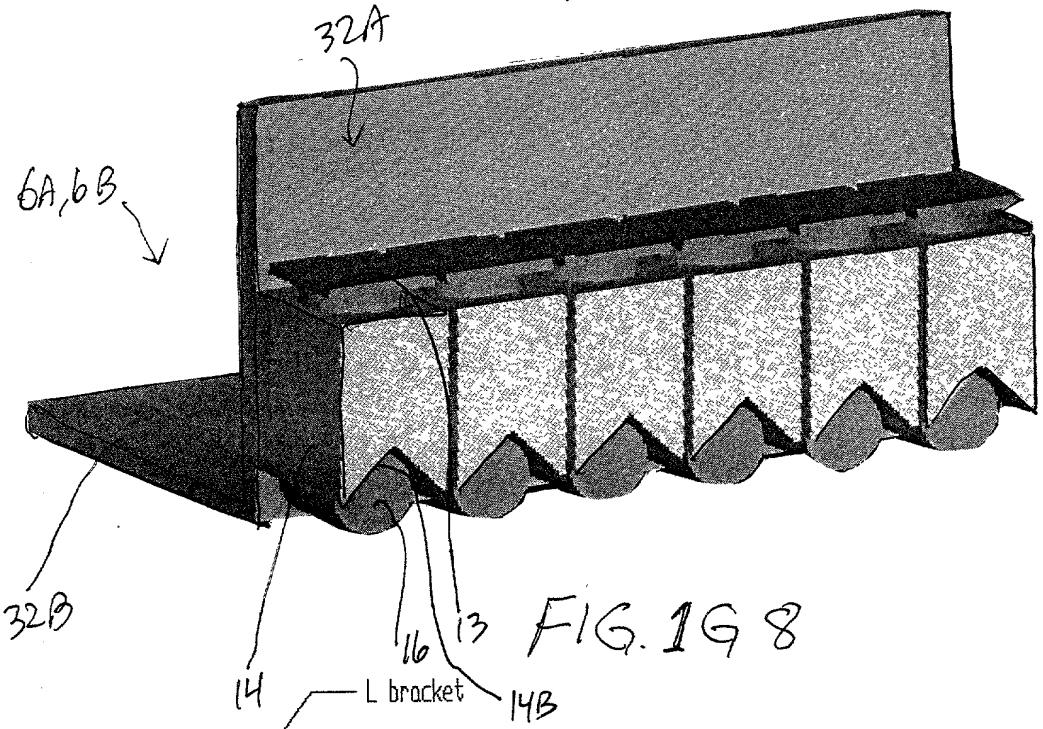


FIG. 1G 8

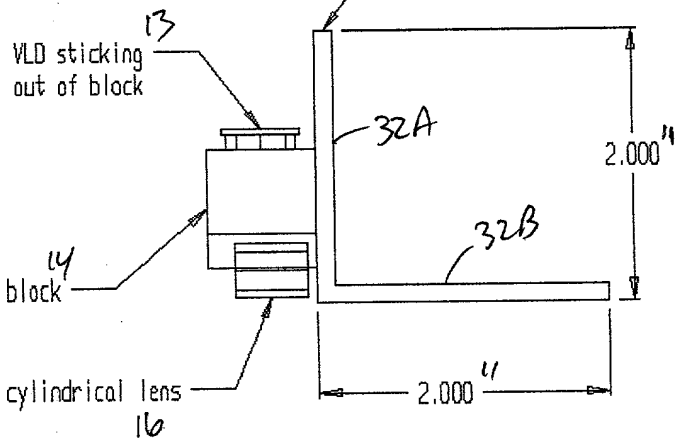


FIG. 1G. 9

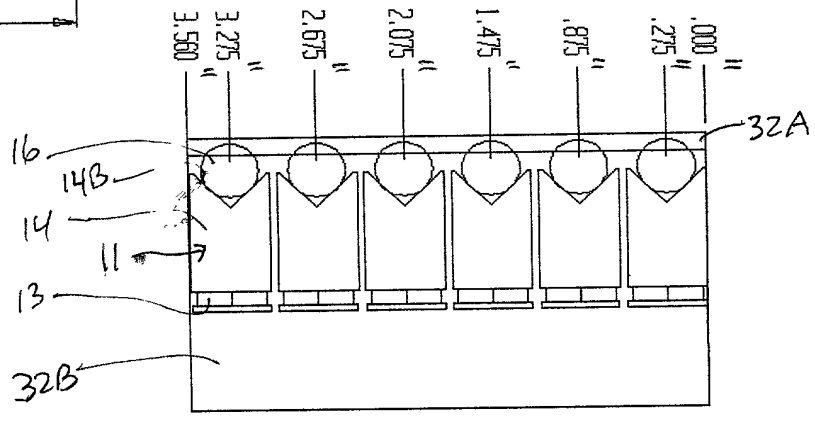


FIG. 1G10

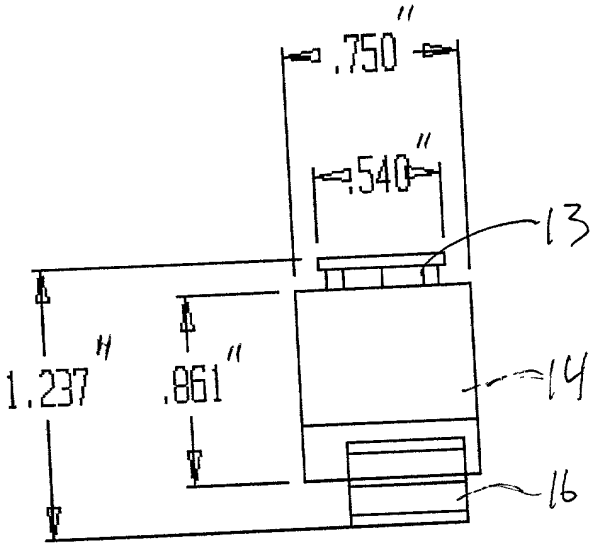


FIG. 16 11

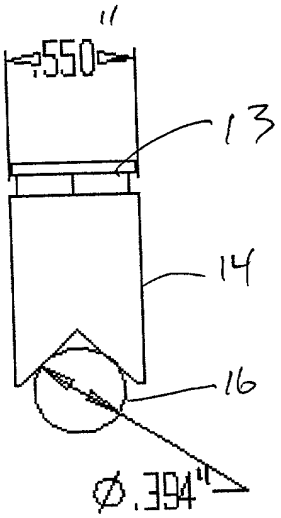


FIG. 16 12

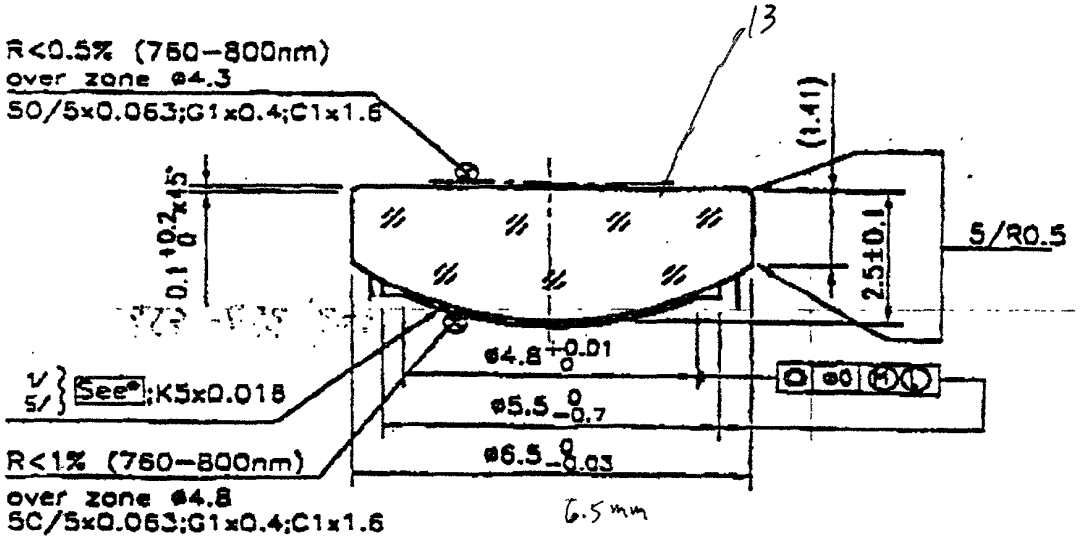


FIG. 1G13

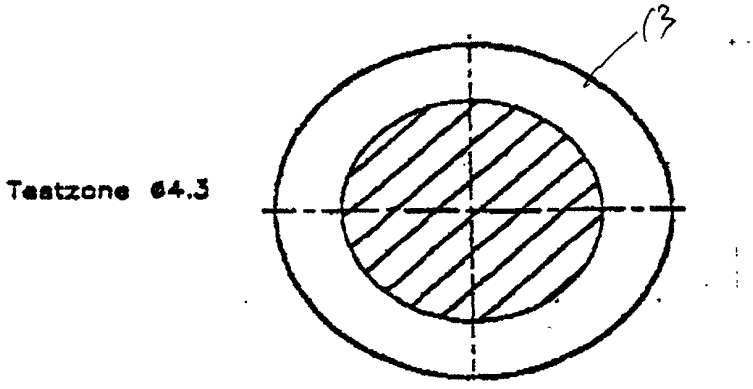


FIG. 1G14

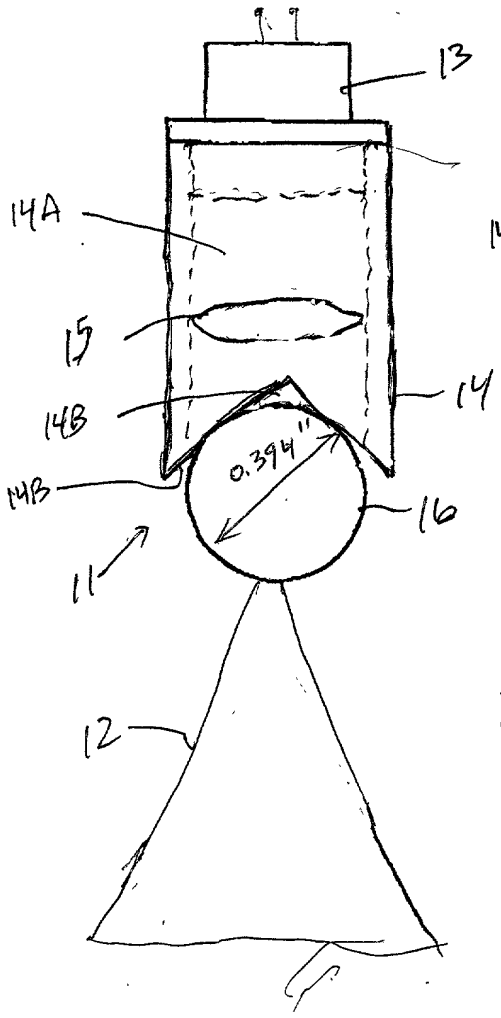


FIG. 1G15A

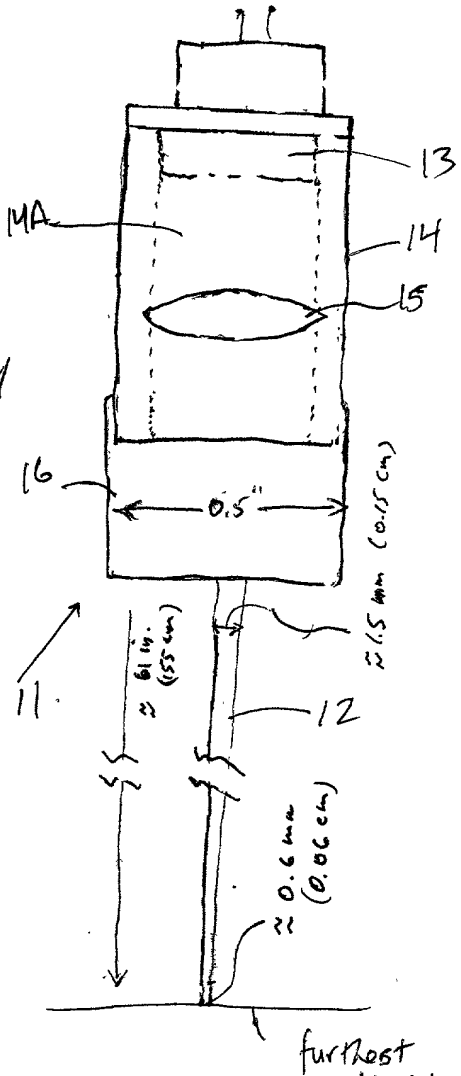


FIG. 1G15B

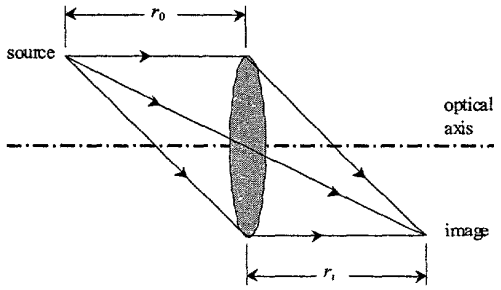


FIG. 1H1

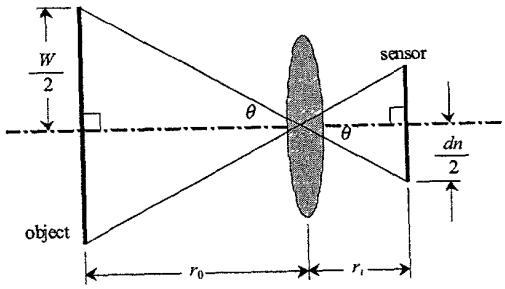


FIG. 1H2

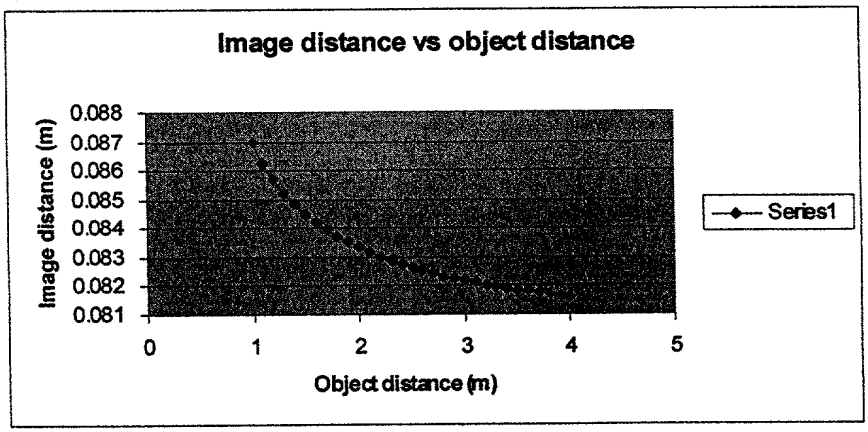


FIG. 1H3

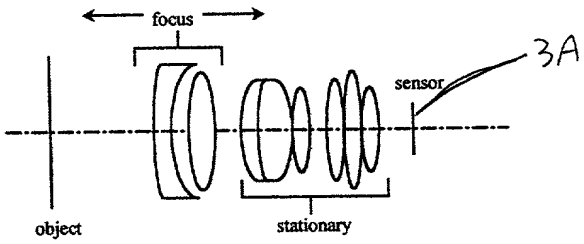


FIG. 1H4

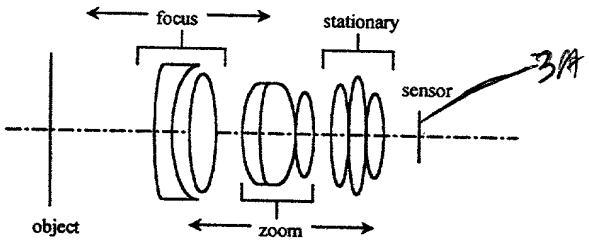


FIG. 1H5

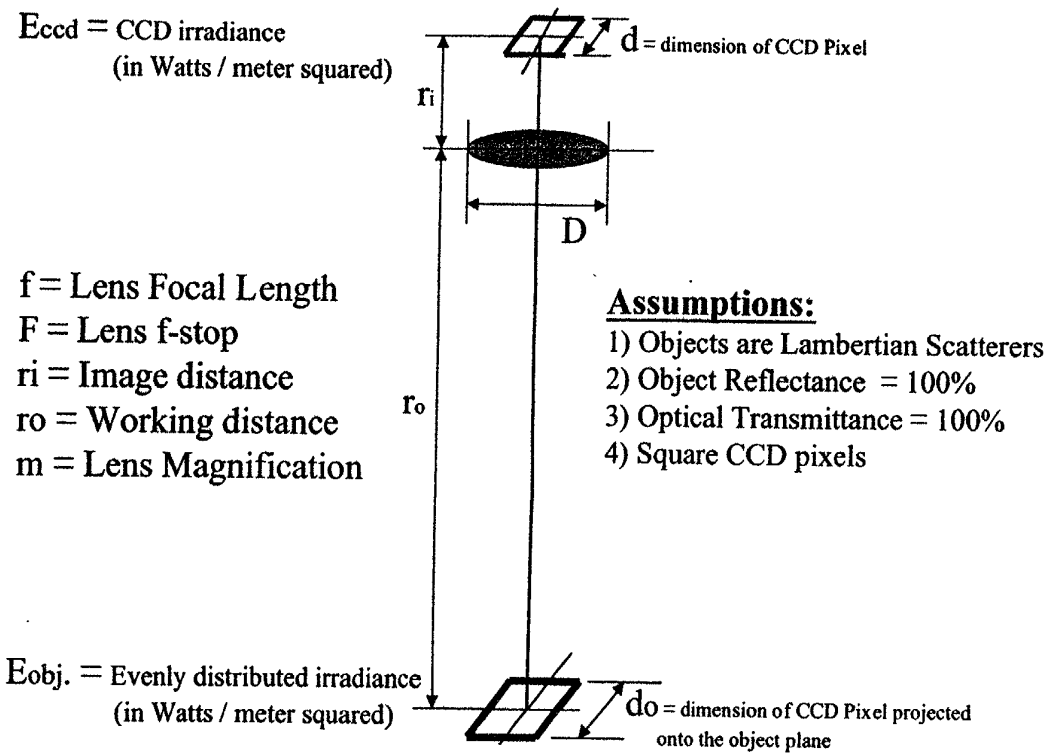
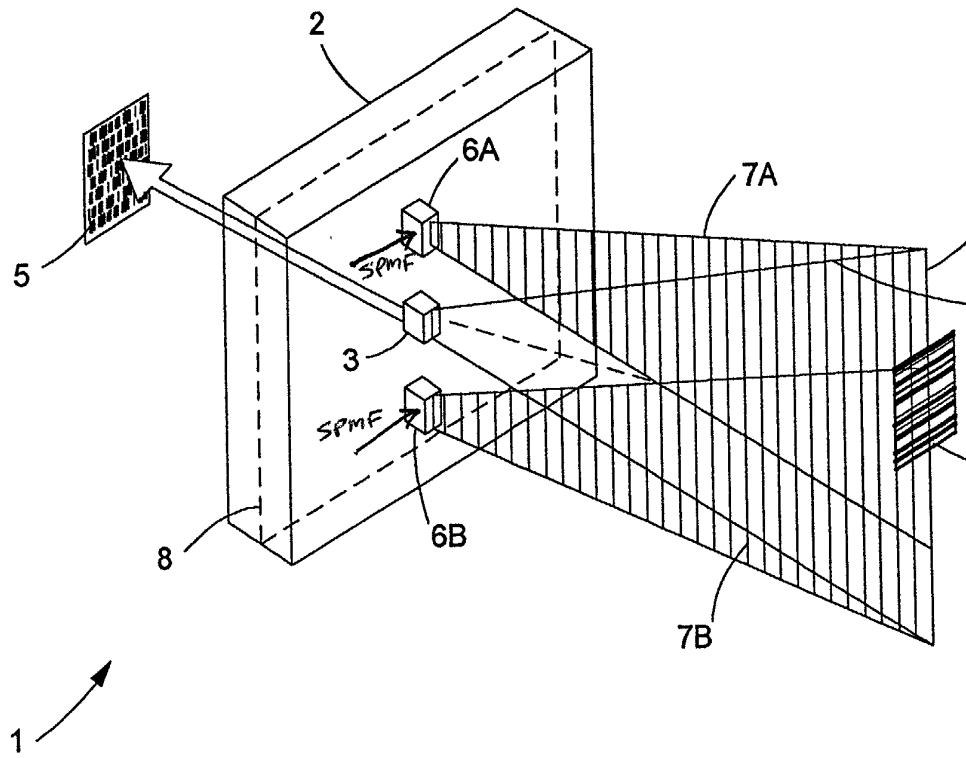

Eccd = CCD irradiance
(in Watts / meter squared)
d = dimension of CCD Pixel
ri
D
f = Lens Focal Length
F = Lens f-stop
ri = Image distance
ro = Working distance
m = Lens Magnification
ro
Assumptions:
1) Objects are Lambertian Scatterers
2) Object Reflectance = 100%
3) Optical Transmittance = 100%
4) Square CCD pixels
Eobj. = Evenly distributed irradiance
(in Watts / meter squared)
do = dimension of CCD Pixel projected
onto the object plane
CCD-Based Scanner

FIG. 1H6



FIRST GENERALIZED METHOD OF Reducing Speckle-Noise PATTERNS AT Image Detection array OF The IFD SubSystem (3)

(SPMF)

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FIG. 1I1

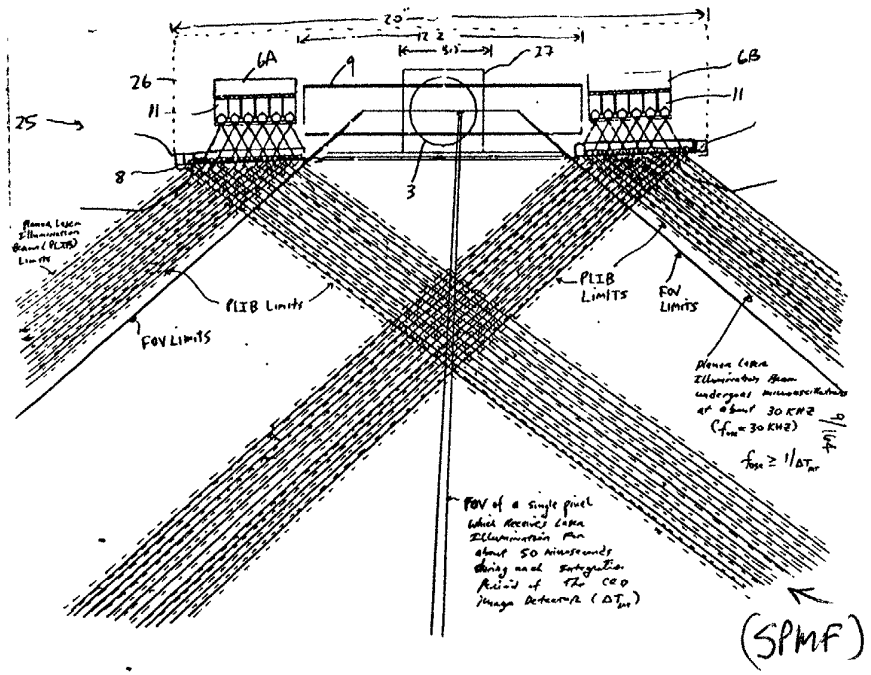


FIG. 11:2A

Prior to object Illumination

The First Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

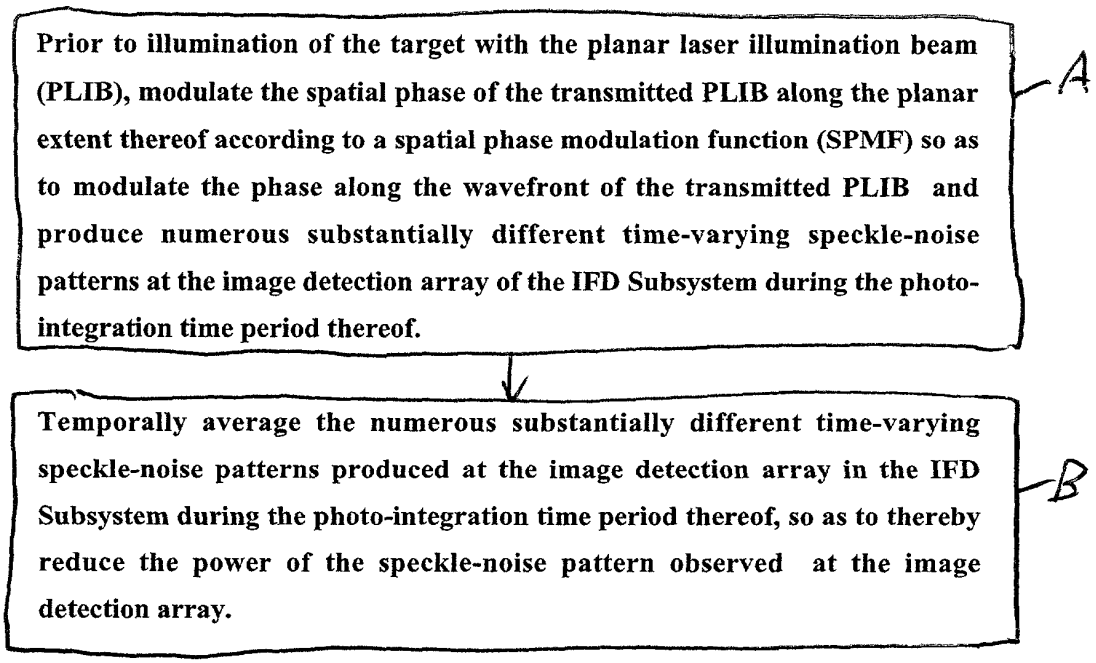


FIG. 1I2B

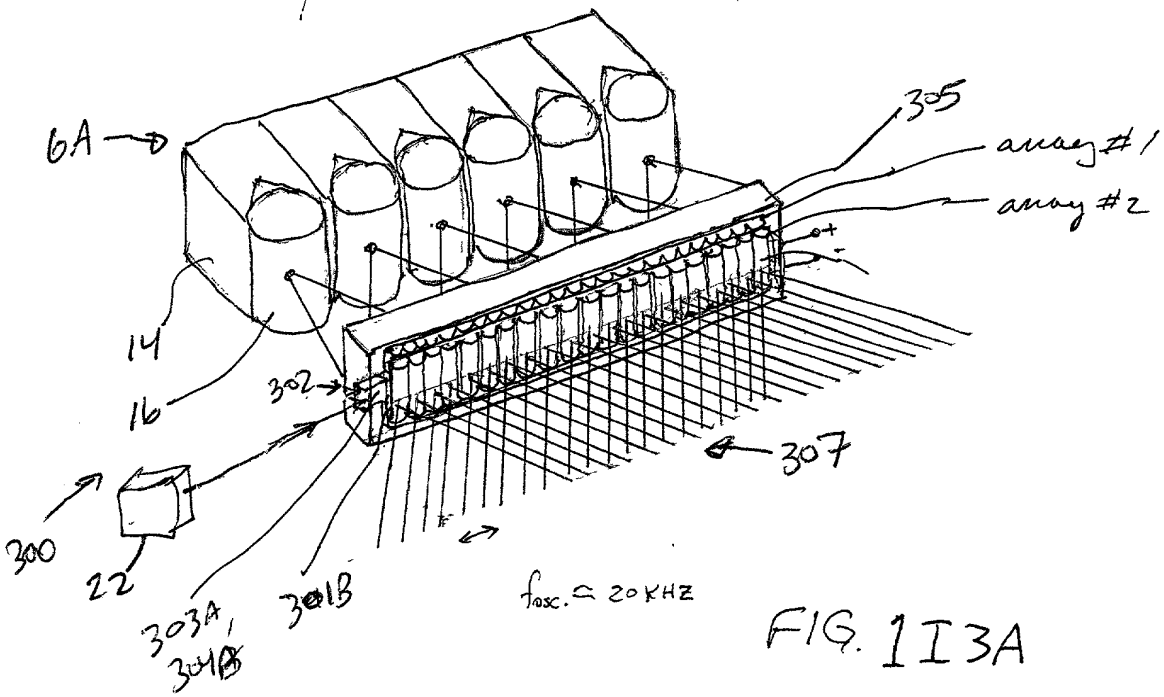


FIG. 1I3A

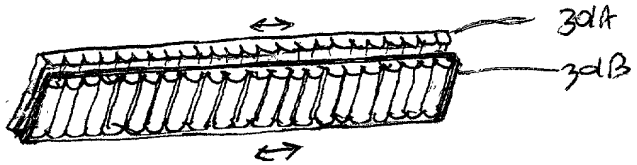


FIG. 1I3B

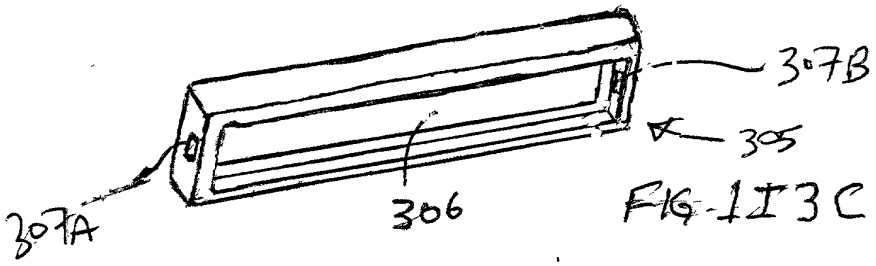


FIG. 1I3C

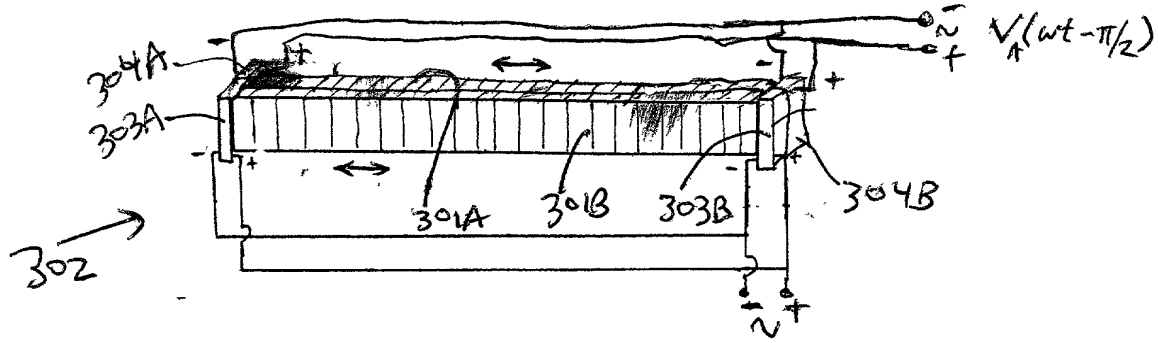


FIG. 1I3D

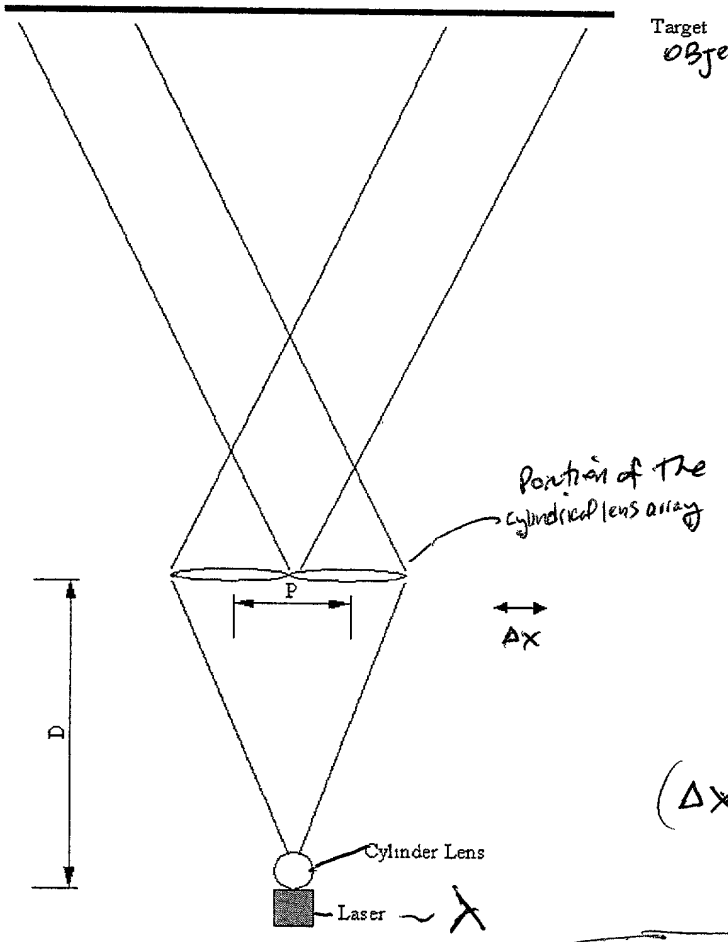


Figure 1

$$(\Delta x / D)\, P = \lambda$$

$$\Delta x \geq \frac{\lambda}{P} \cdot D$$

FIG. 1I3E

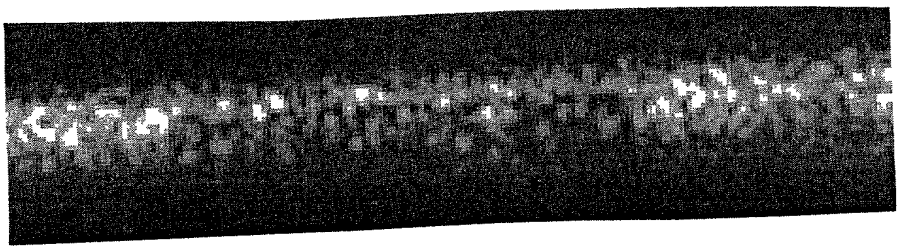


FIG. 1I3F

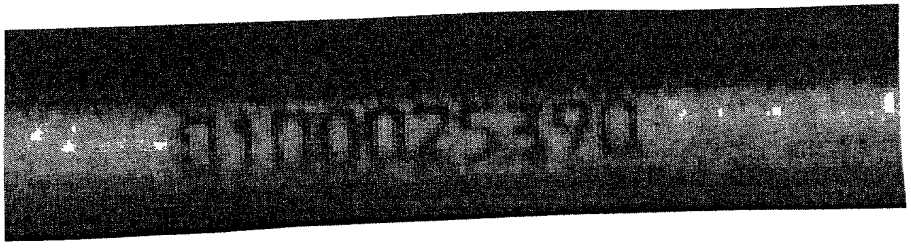


FIG 1I3G

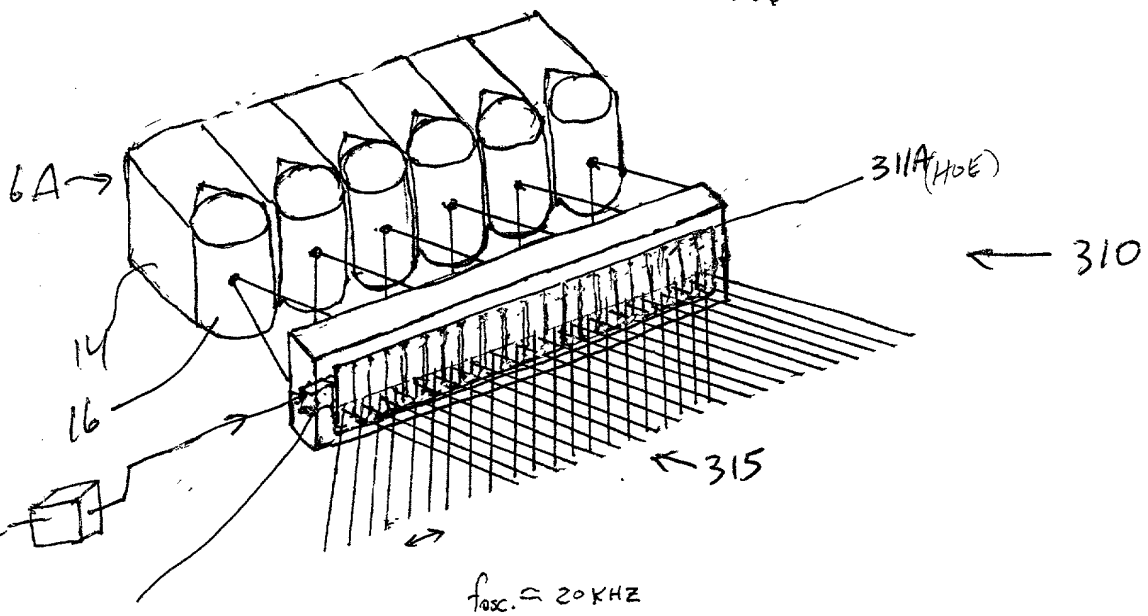


FIG 1I4A

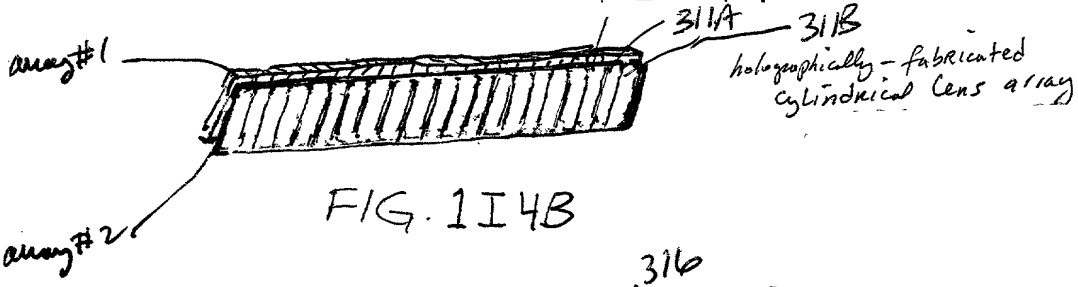


FIG. 1I4B

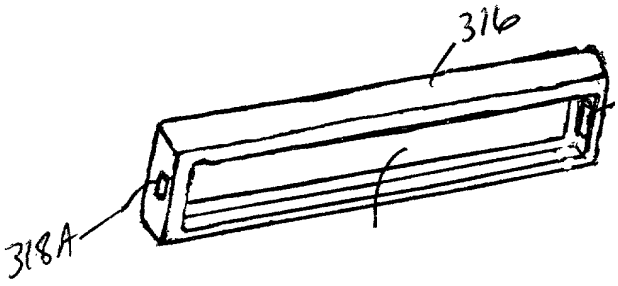


FIG 1I4C

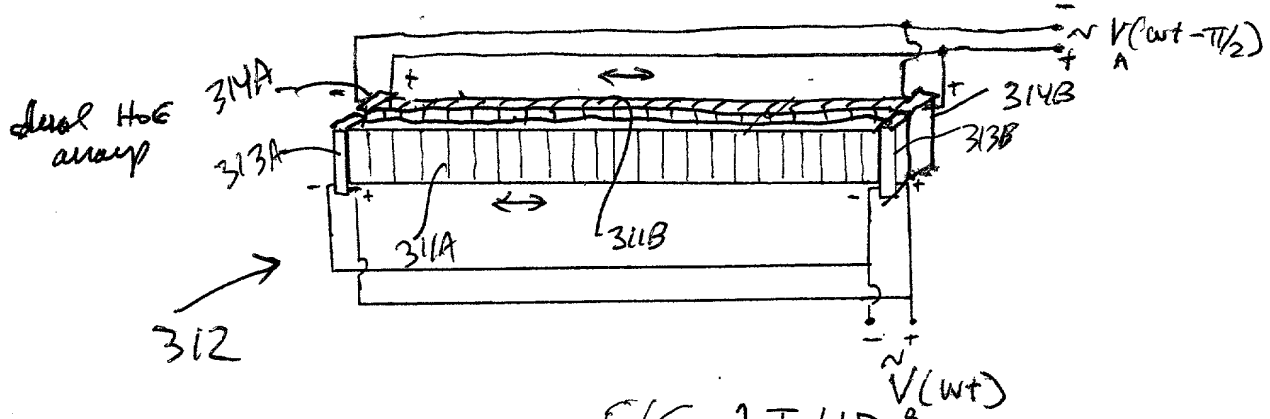


FIG. 1I4D

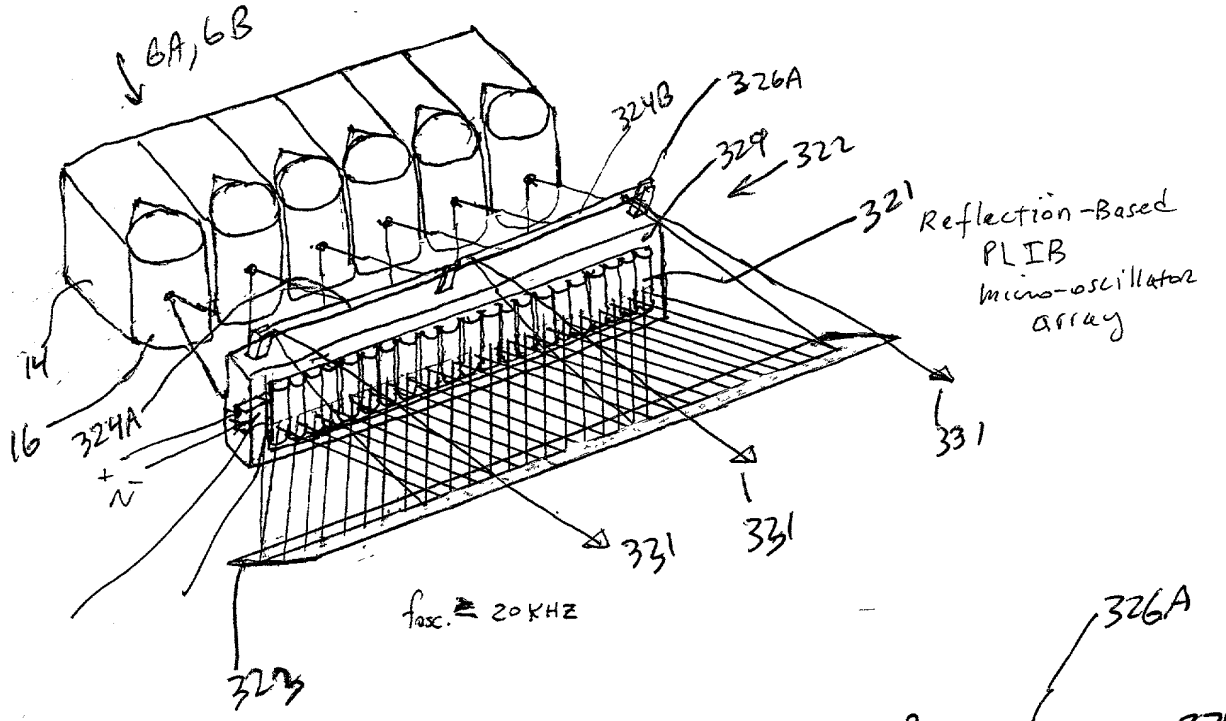


FIG. 1I5A

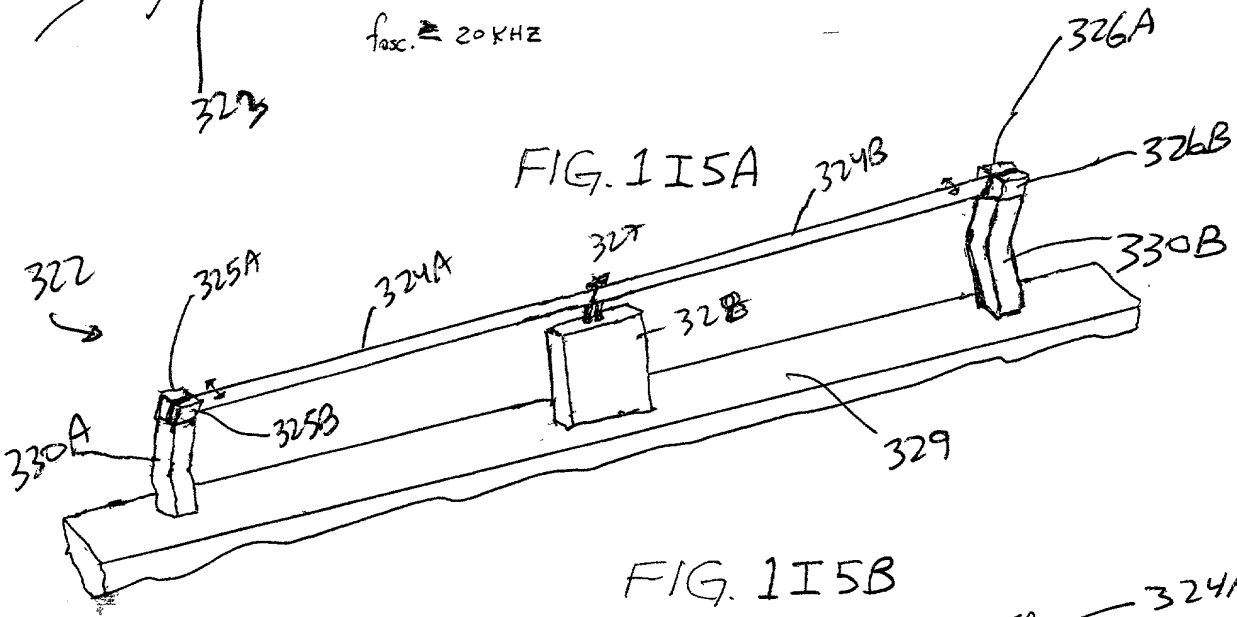


FIG. 1I5B

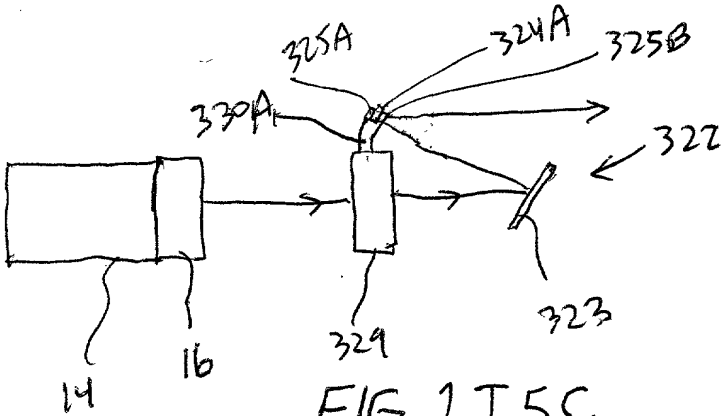


FIG. 1I5C

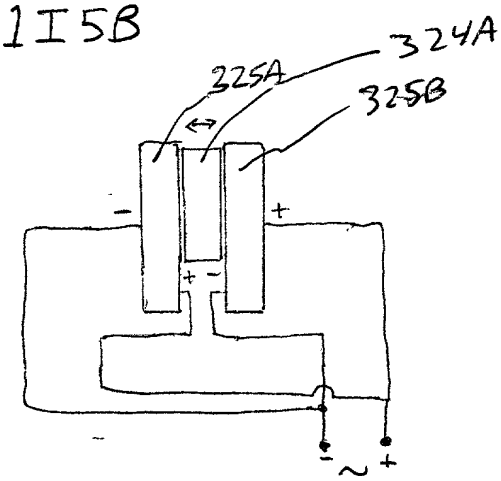


FIG. 1I5D

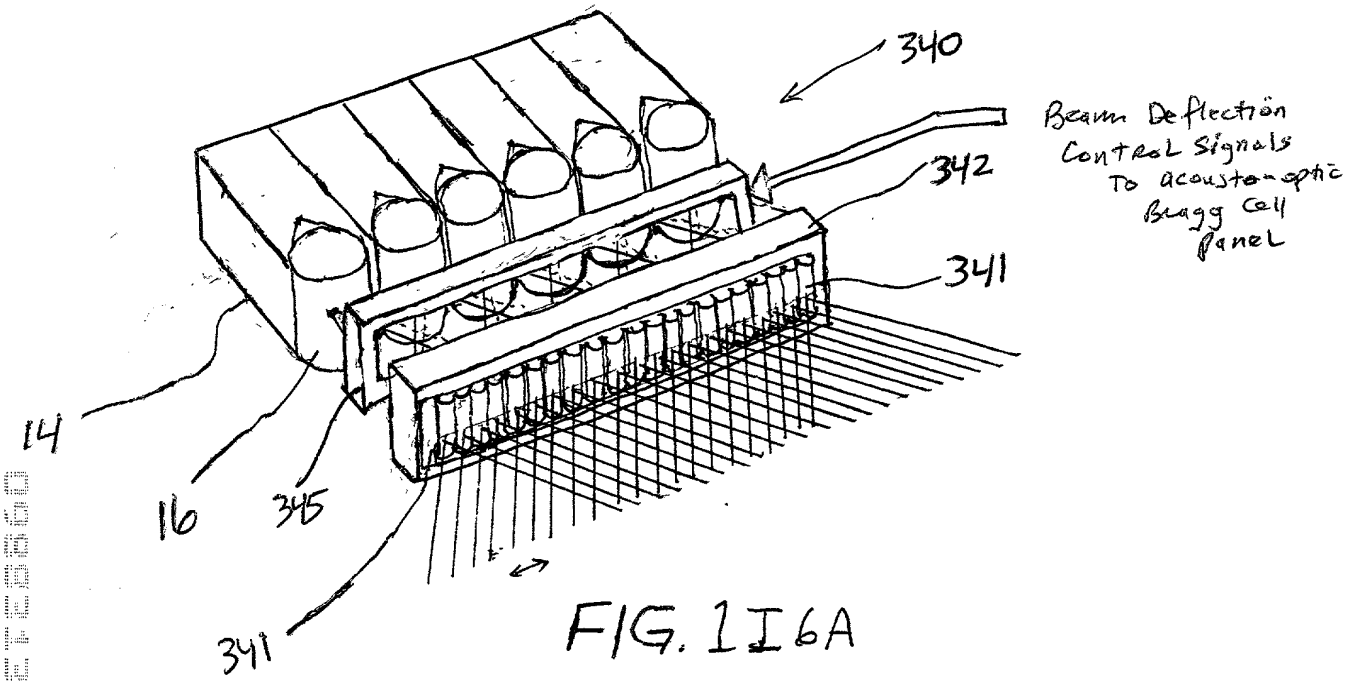


FIG. 1I6A

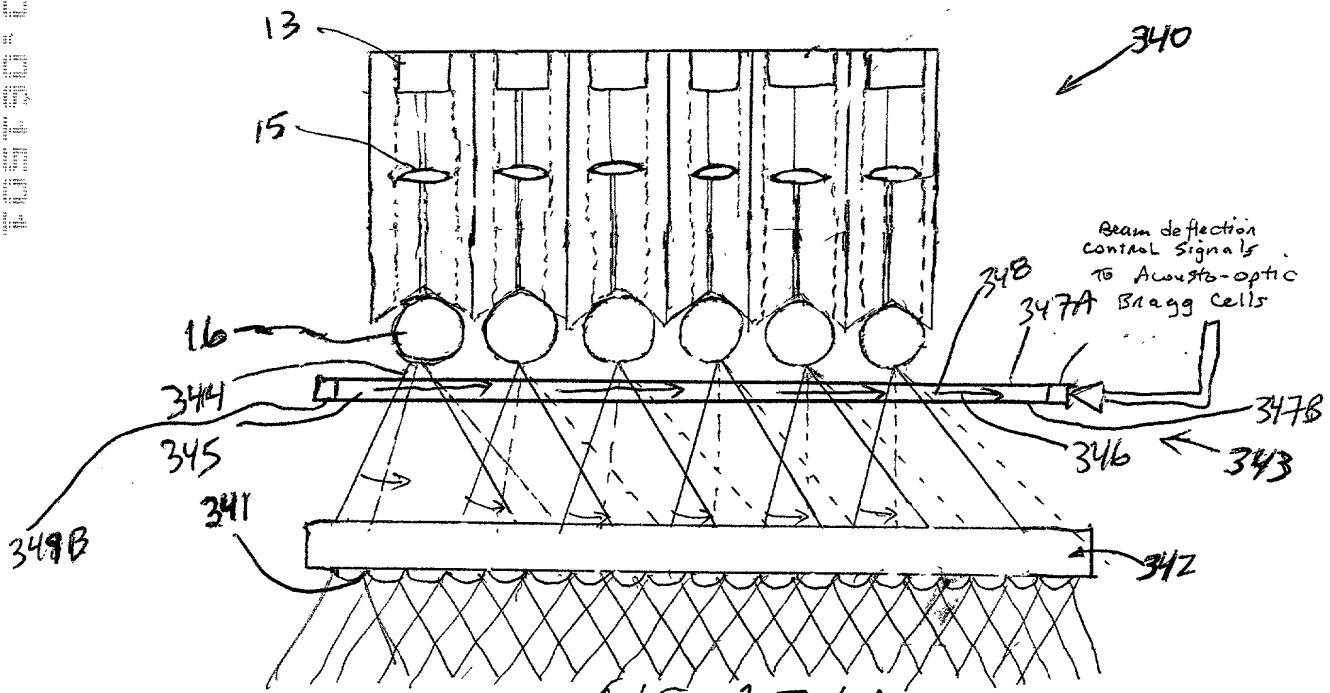


FIG. 1I6A

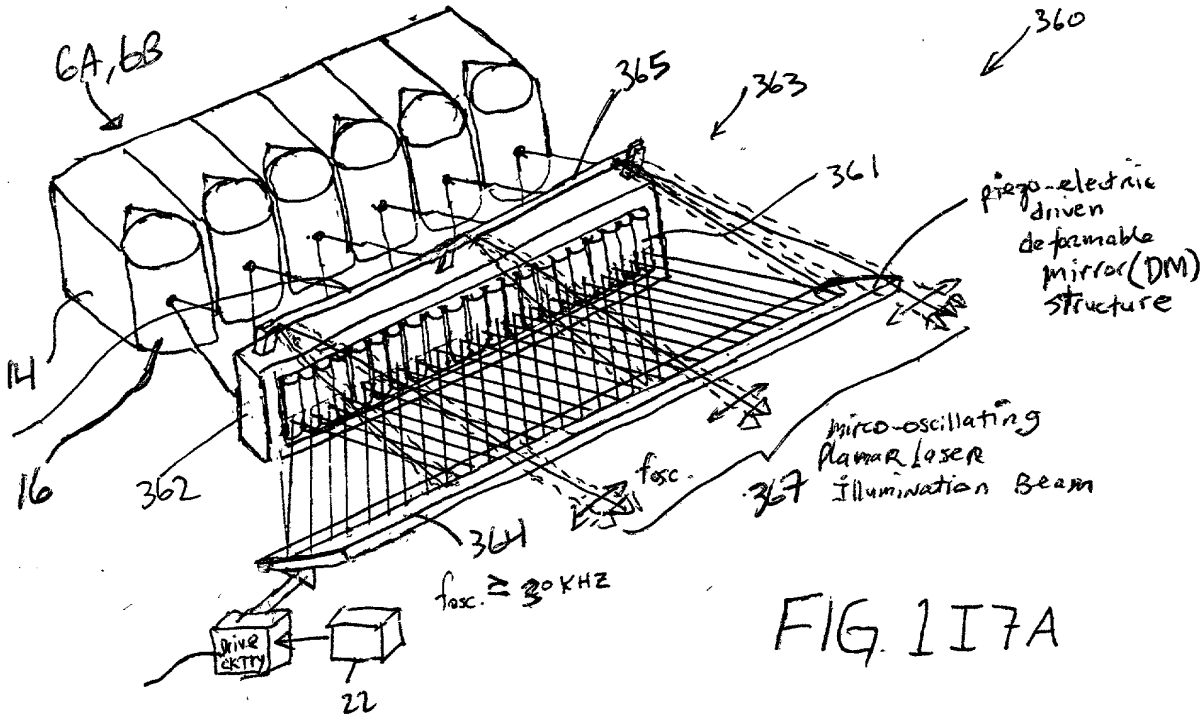


FIG. 1I7A

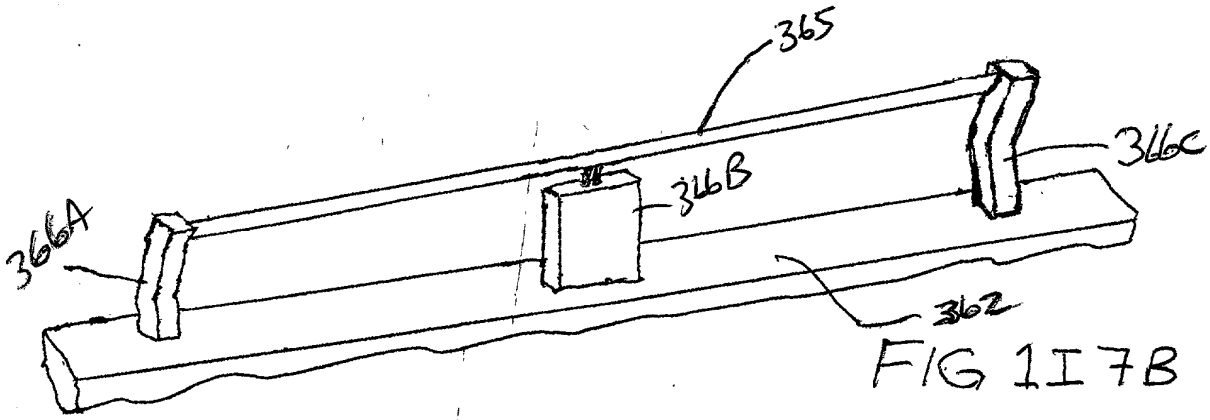


FIG 1I7B

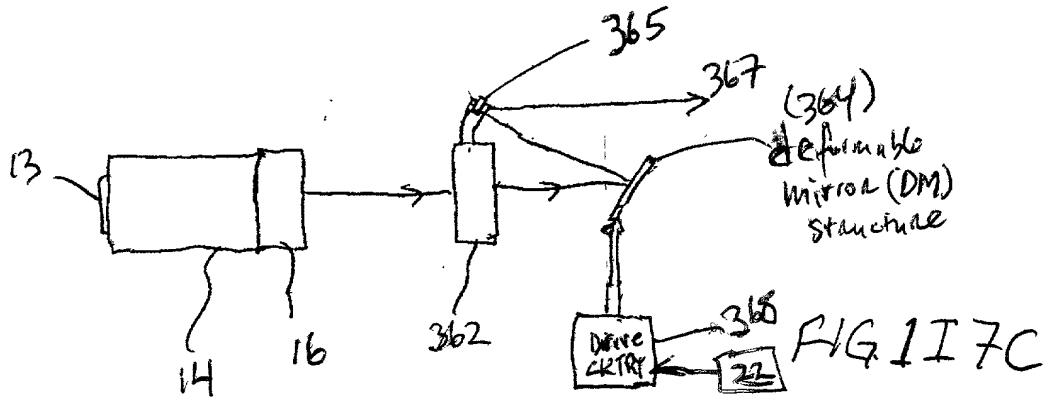


FIG 1I7C

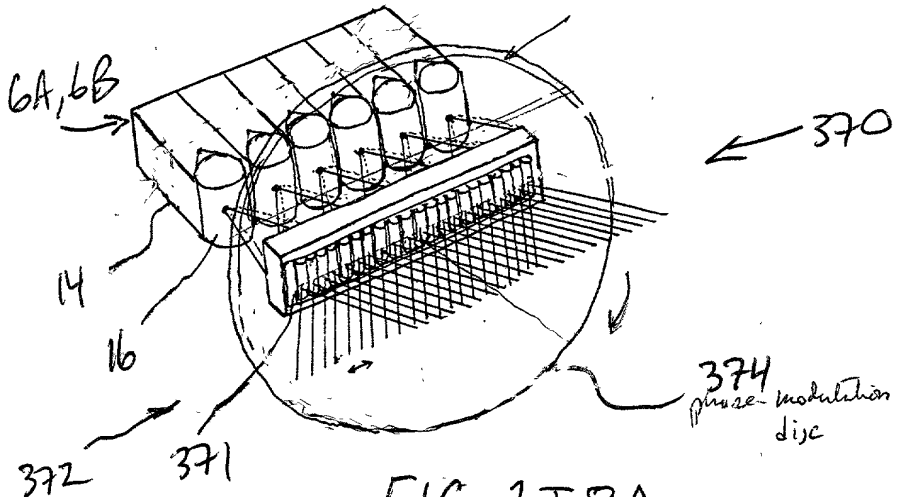


FIG. 1I8A

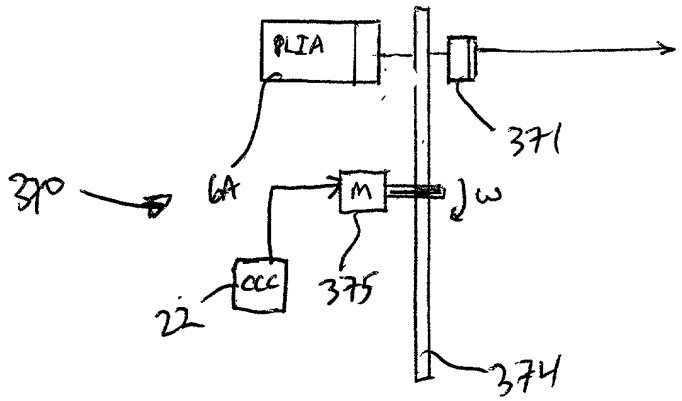


FIG. 1I8B

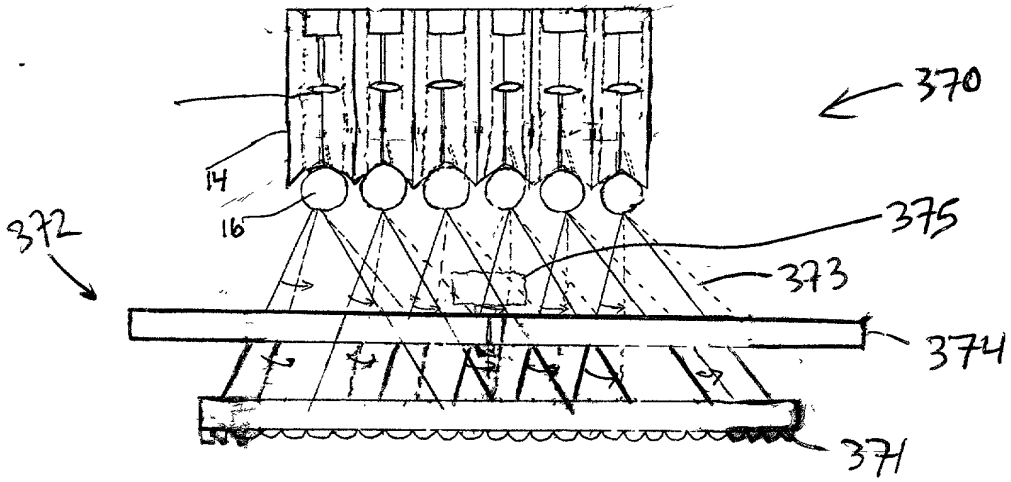


FIG. 1I8C

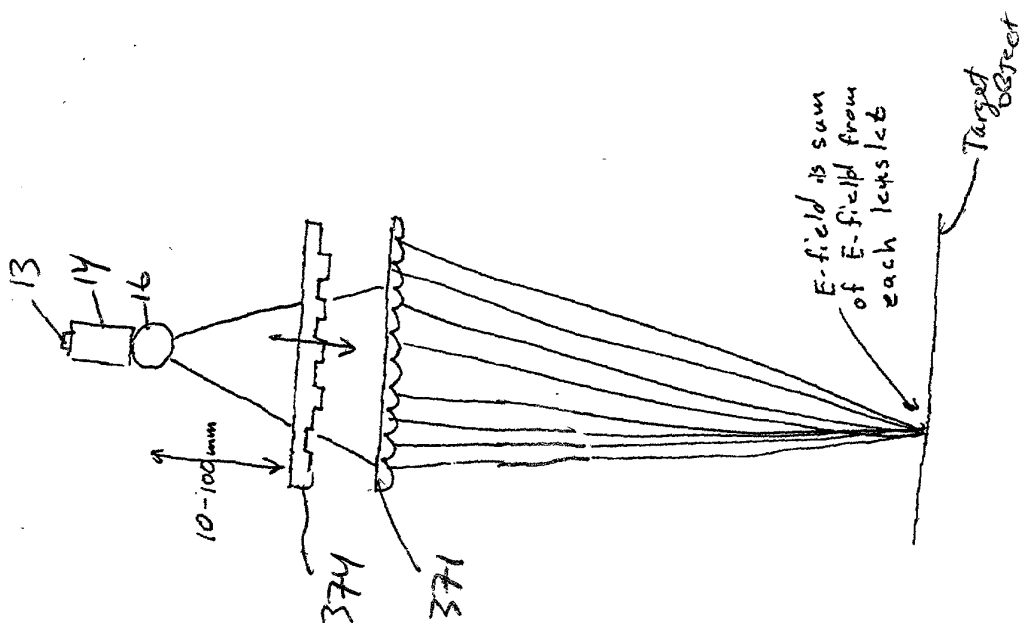


FIG 1I8E

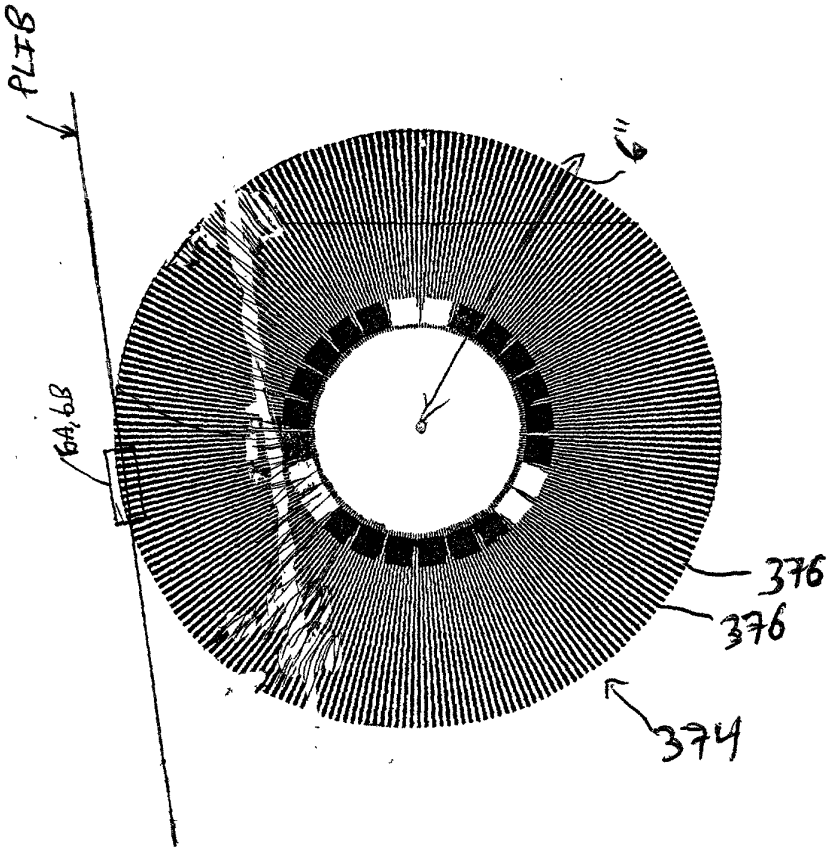


FIG 1I8D

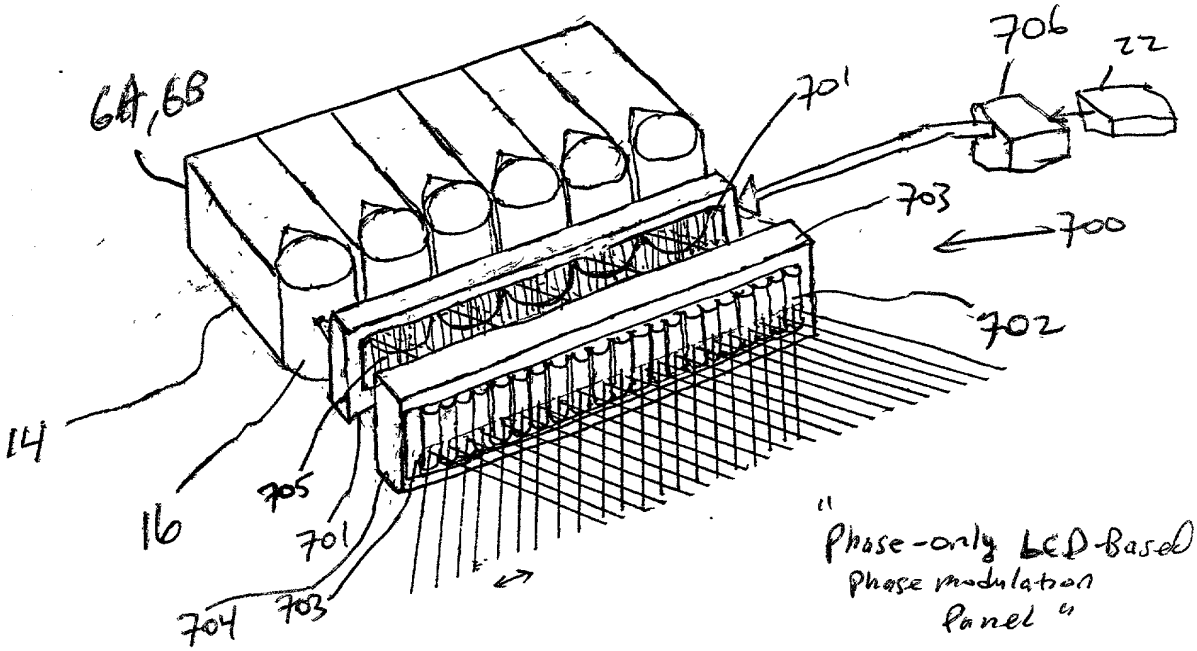


FIG.1I8F

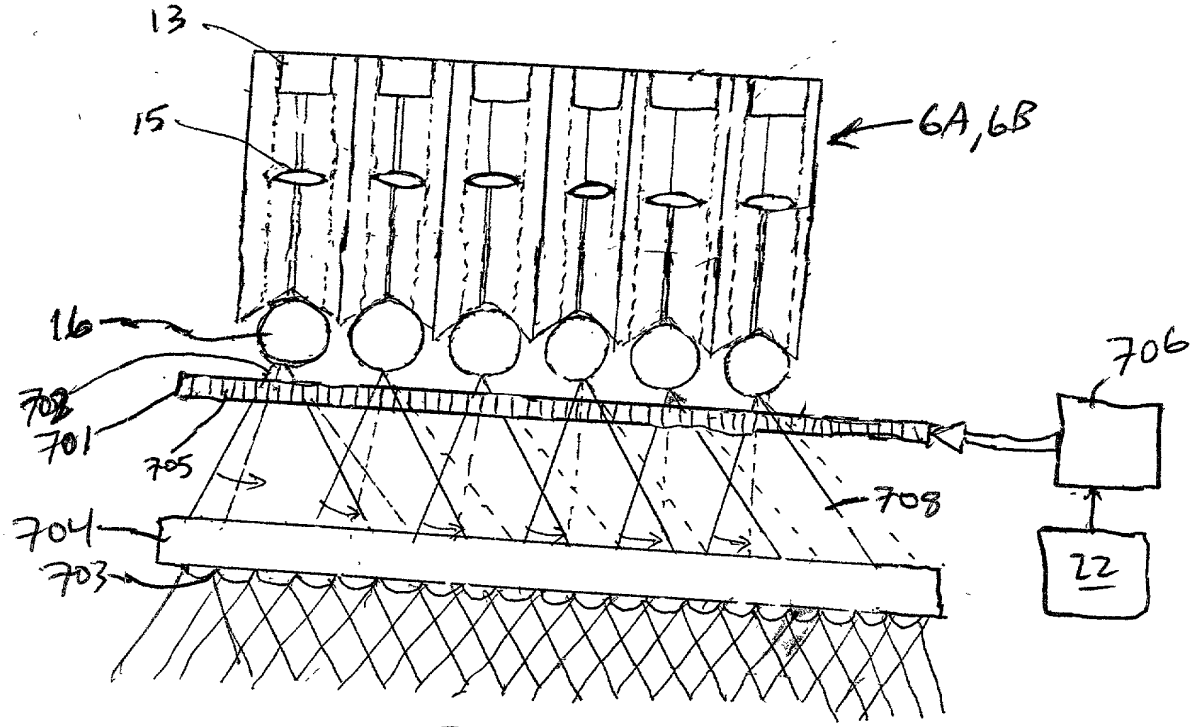


FIG.1IG

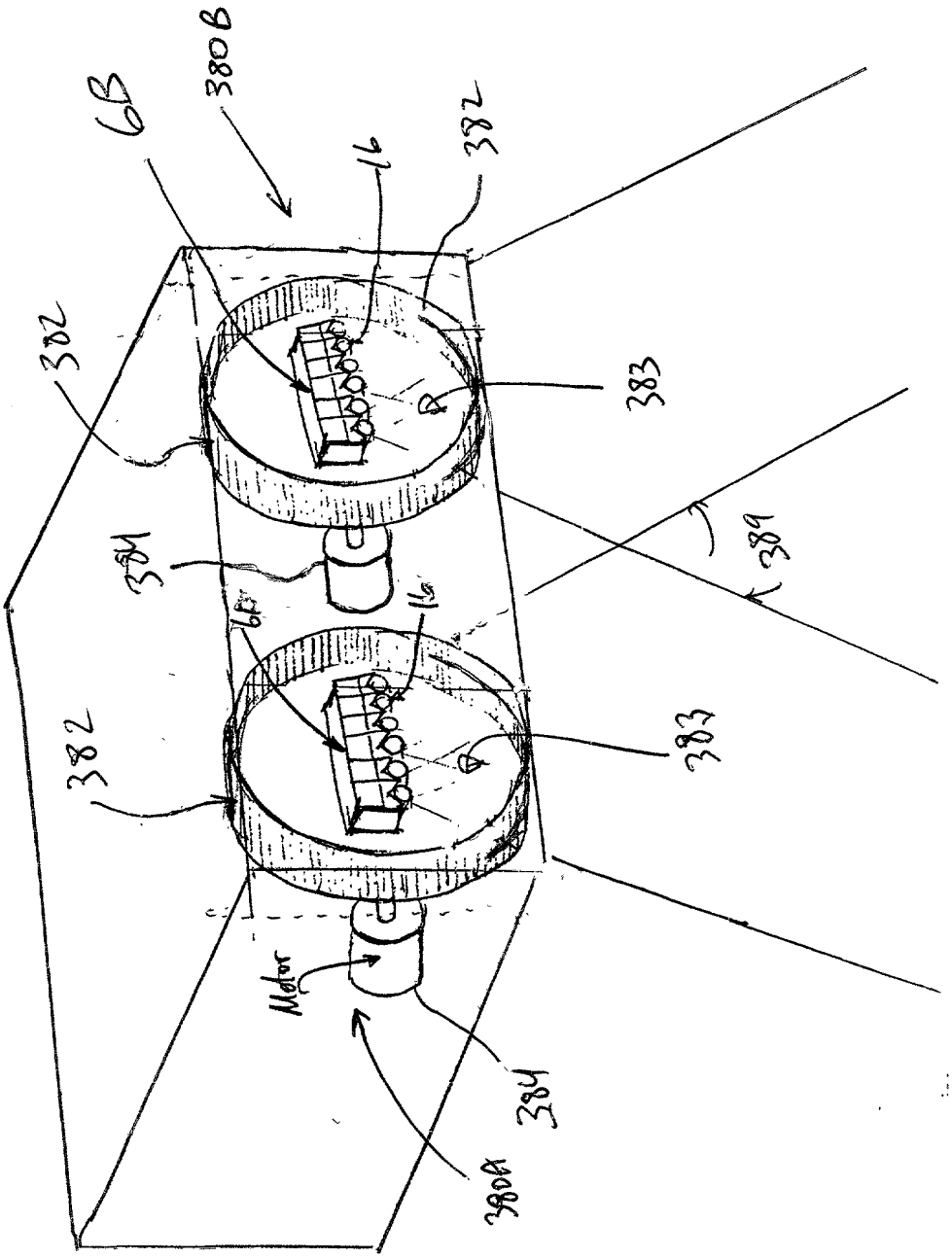


FIG. 11A

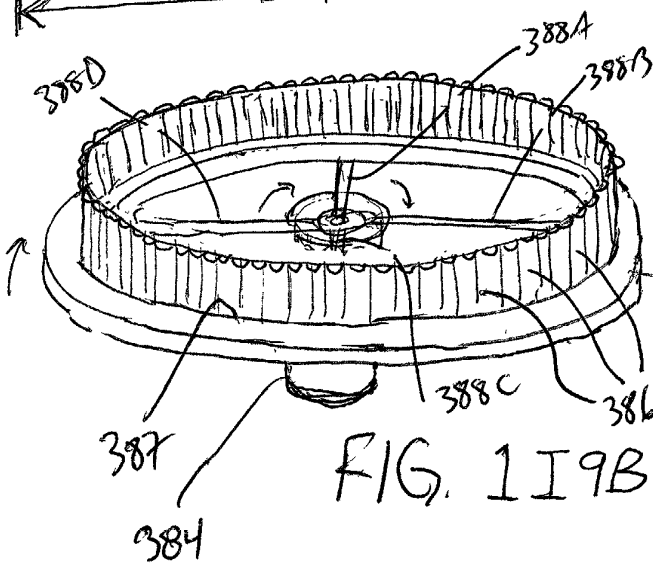


FIG. 1I9B

optical specifications:

- 30 cylindrical lens (lines) per linear inch
- focal length ≈ 2.0 millimeters
- diameter of lenticular carousel ≈ 4 inches
- acrylic material
  - lenticular cylindrical elements on inside diameter

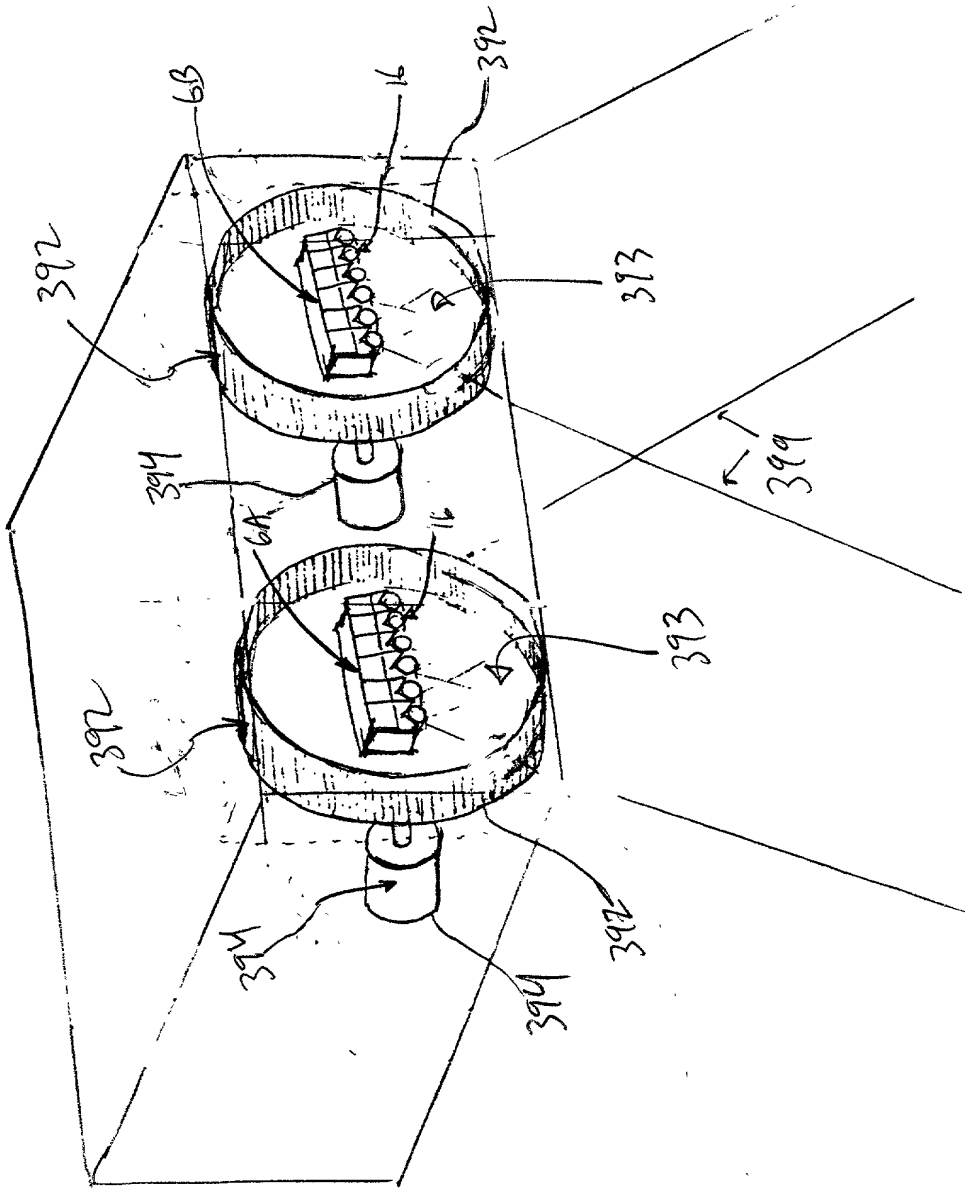


FIG. 11 10A

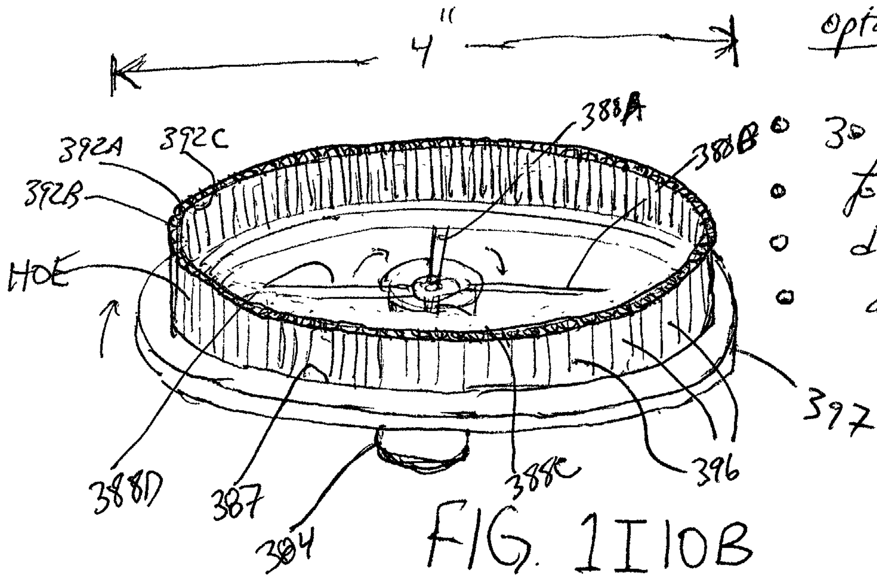


FIG. 11110B

optical specifications:

- 30 cylindrical lens (lines) per linear inch
- focal length ≈ 2.0 millimeters
- diameter of lenticular carousel ≈ 4 inches
- arcylic material
  - lenticular cylindrical elements on inside diameter

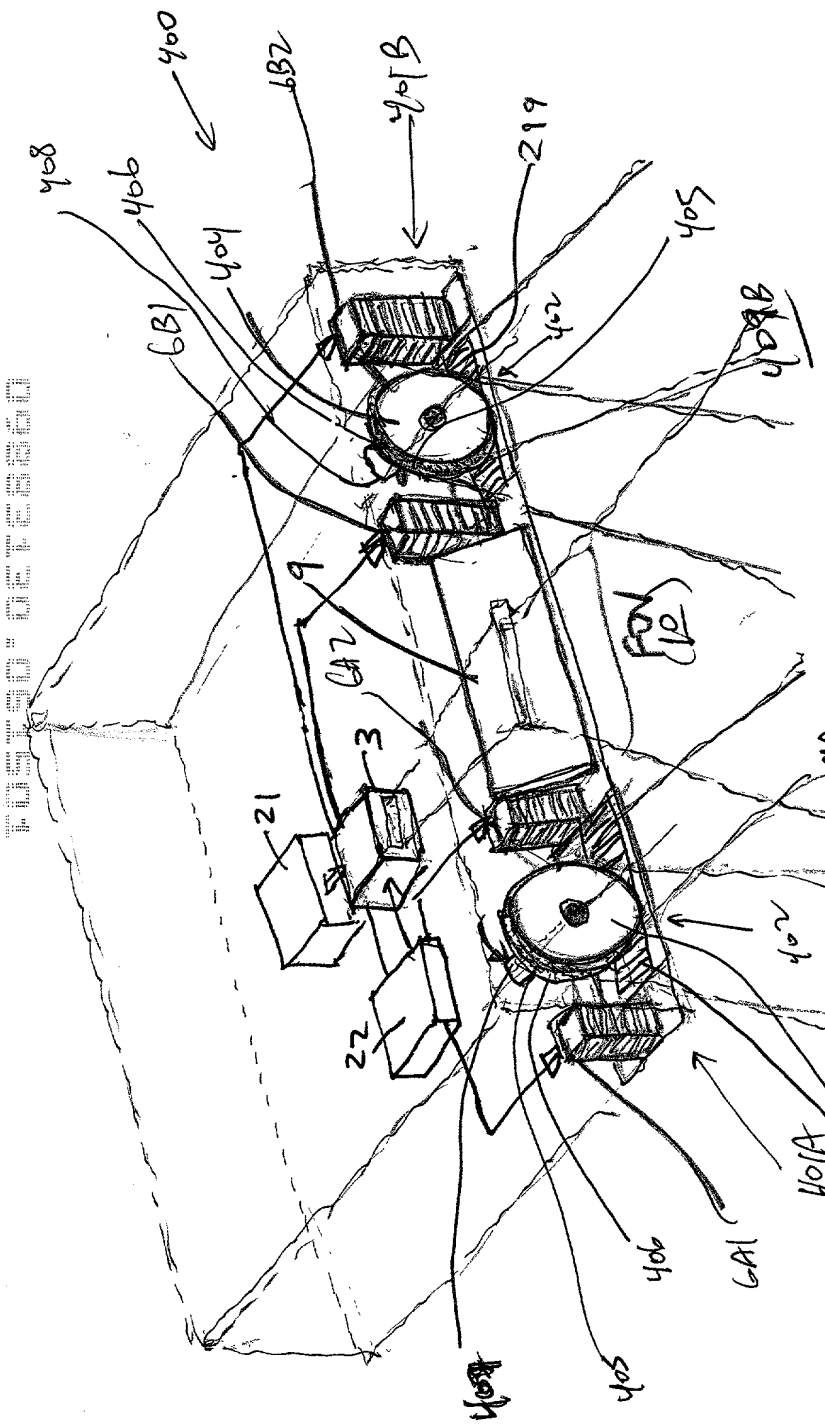


FIG. 11A

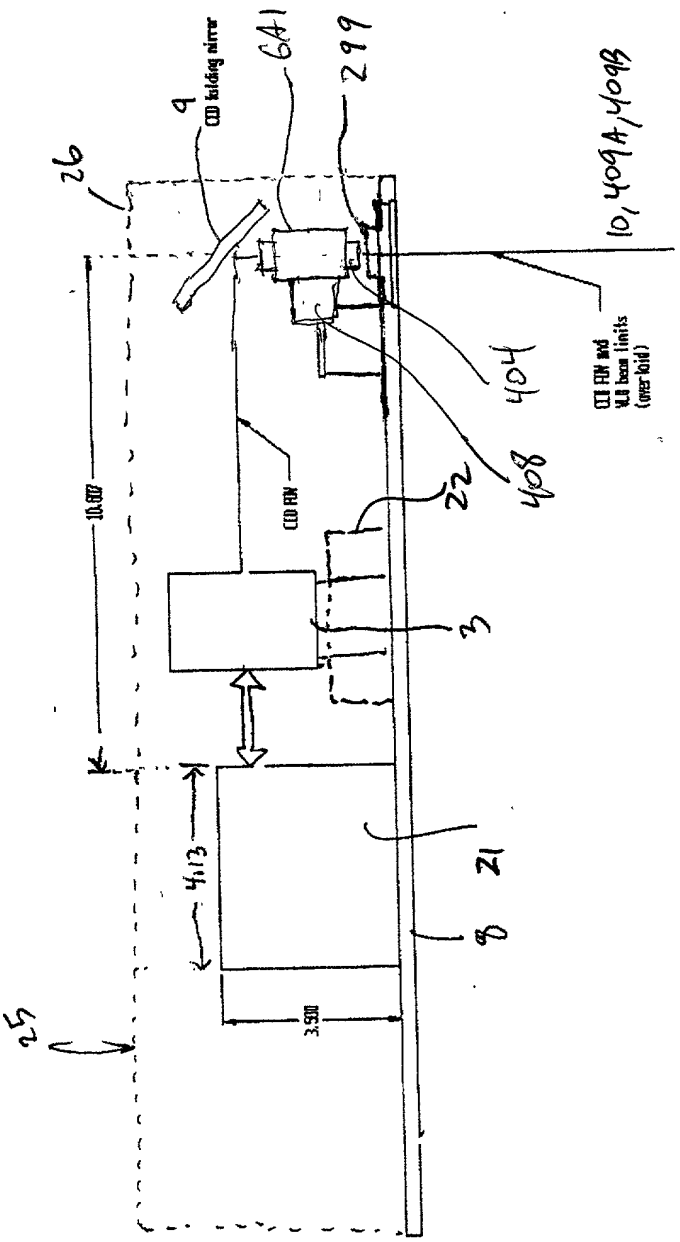

9
CCD folding mirror
641
299
26
10,409A,409B
CCD FOV and
VLD beam limits
(over-laid)
404
408
22
CCD FOV
10.000
3
4.113
21
8
3.500
25

FIG 11B

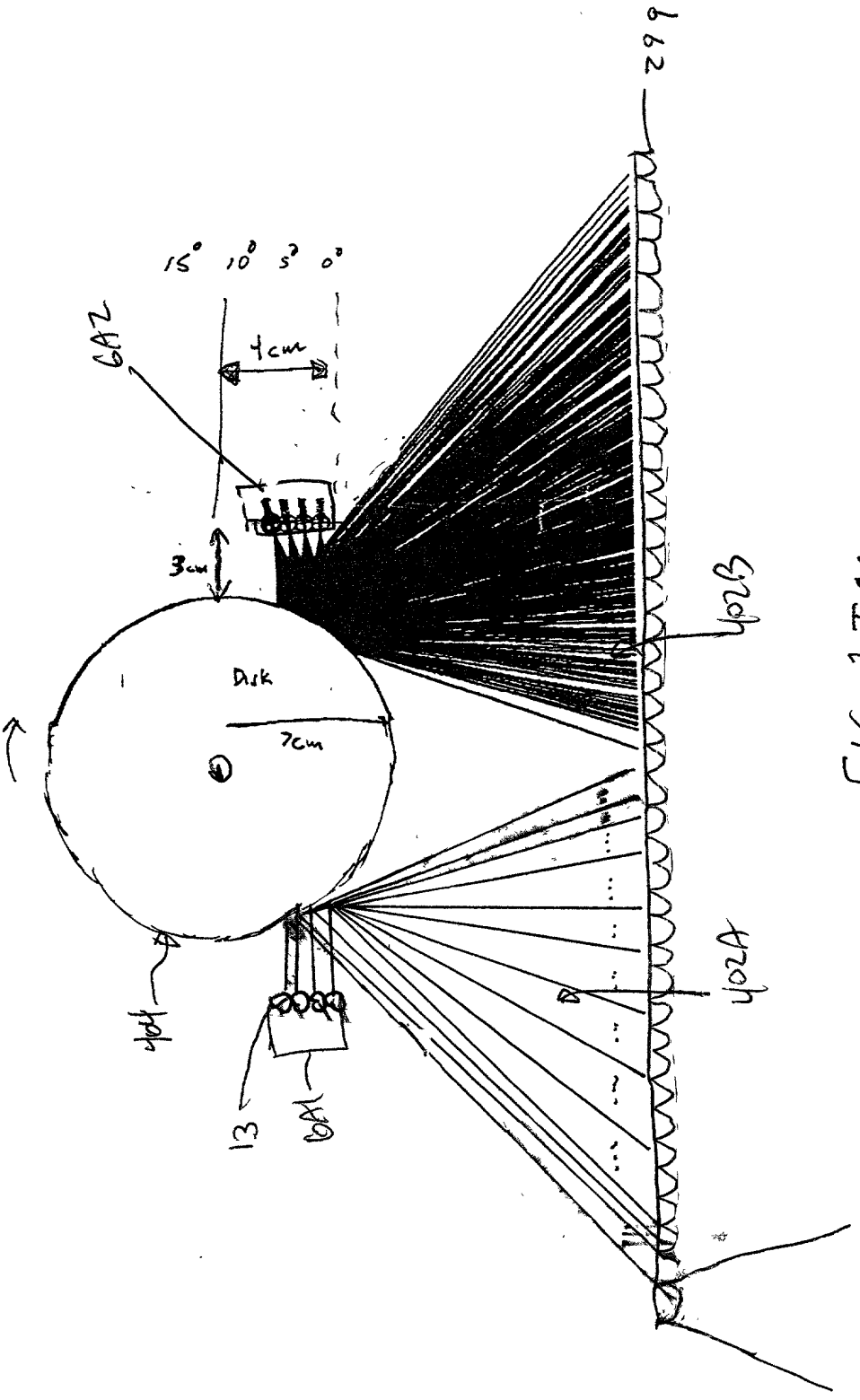


FIG. 1I1C

Second Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem (3)

(TIMF)

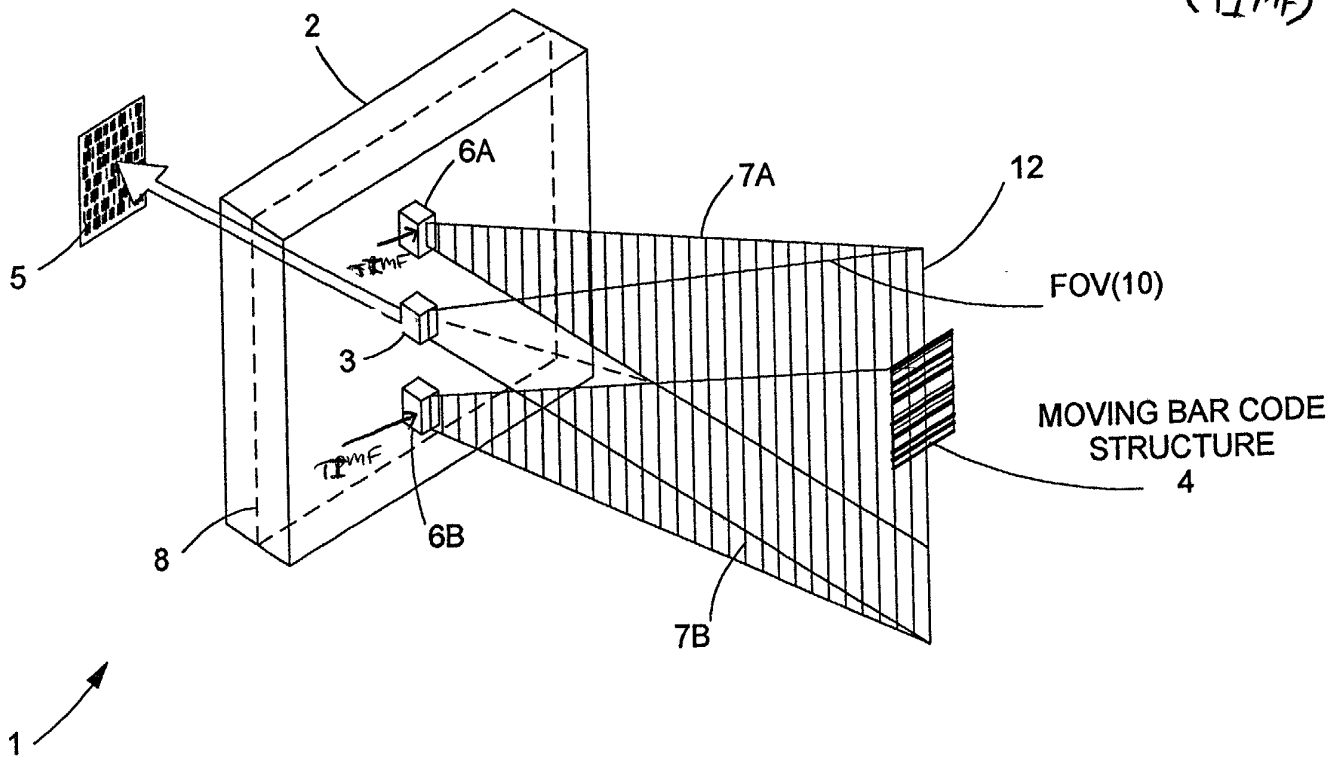


FIG. 1 I 12

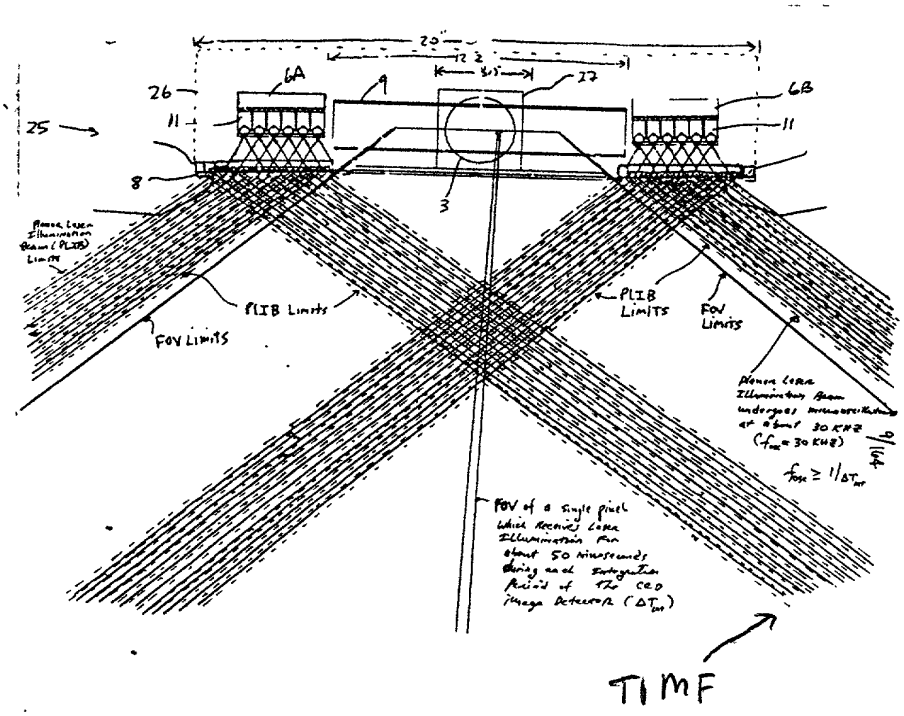

20
17
6A
6B
26
11
25
8
3
9
PLIB Limits
FOV Limits
PLIB Limits
FOV Limits
FOV of a single pixel which receives Laser Illumination for about 50 nanoseconds during each Integration Period of the CCD Image Detector (ΔT_{int})
9/64
$f_{min} \geq 1/\Delta T_{int}$
TIMF

FIG. 1I 13A

The Second Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

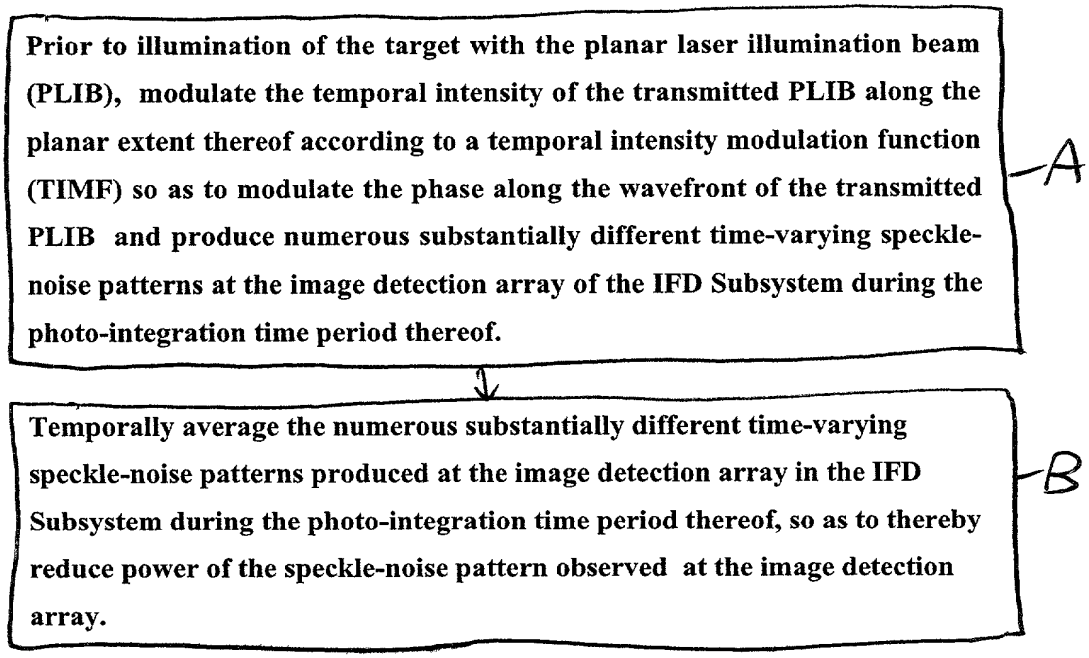


FIG. 1I13B

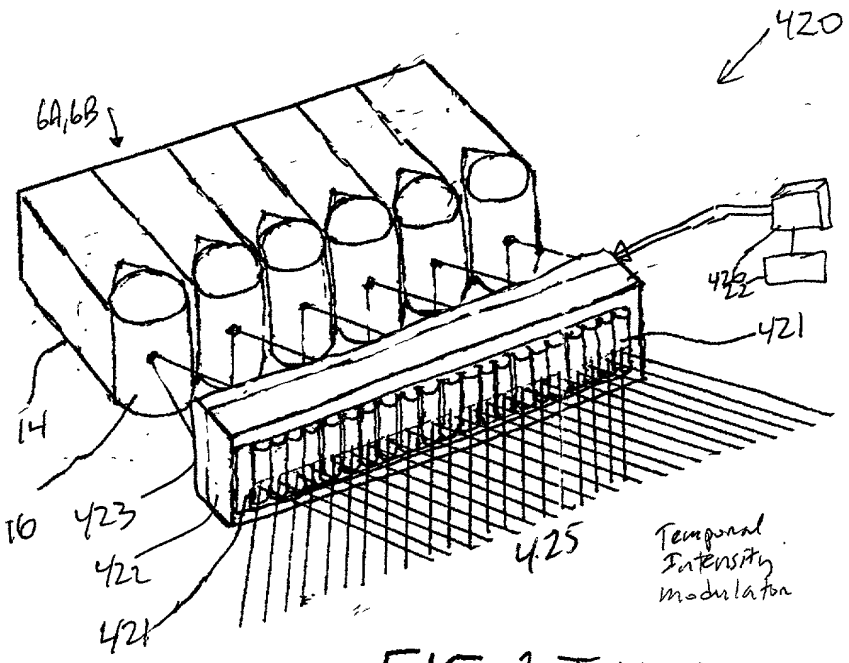


FIG. 1I14A

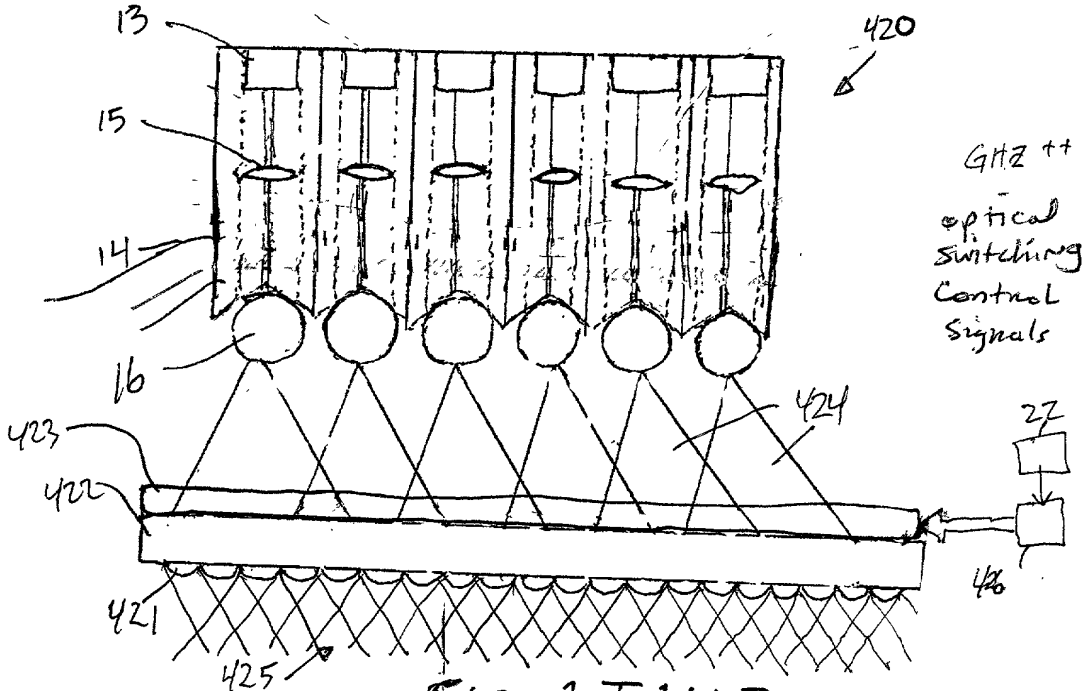


FIG. 1I14B

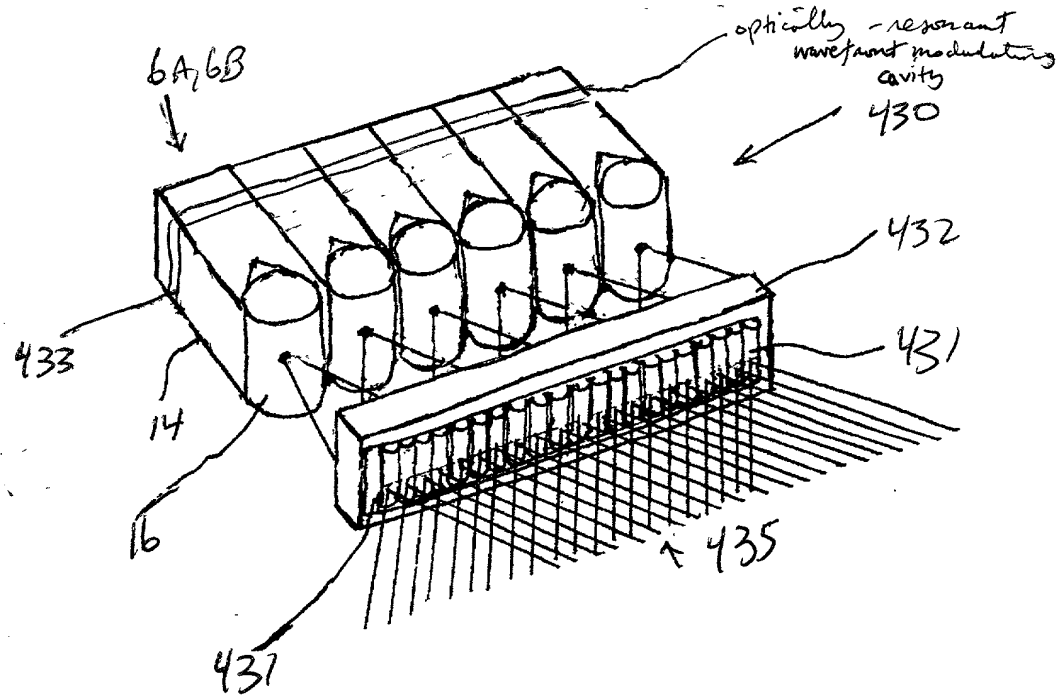


FIG. 1I15A

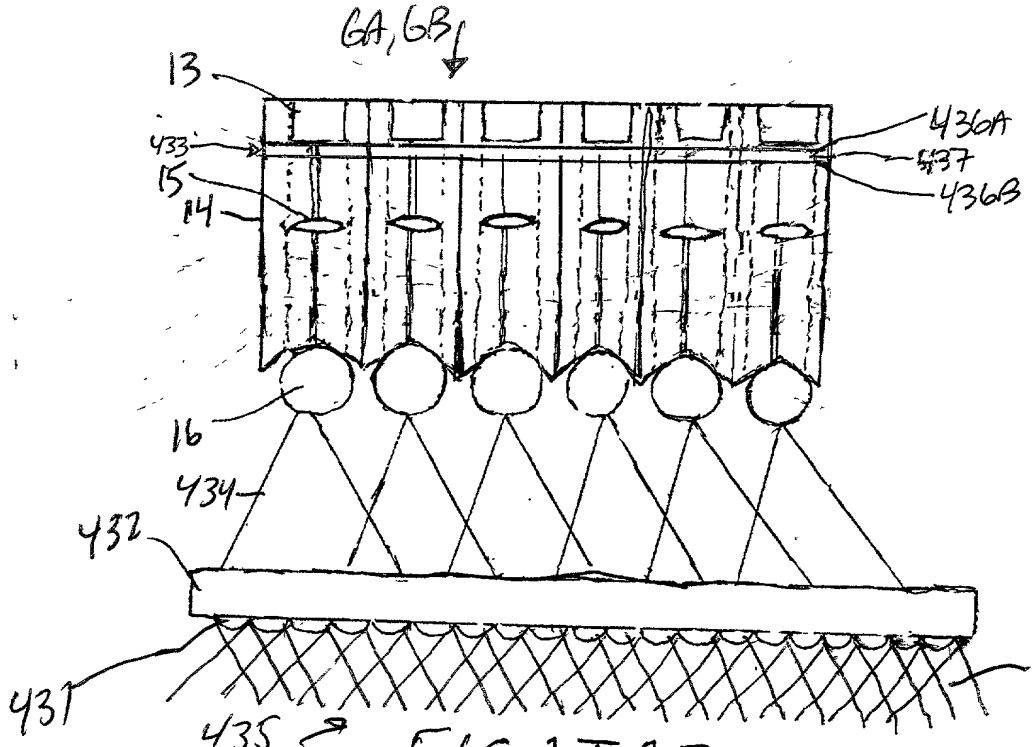


FIG. 1I15B

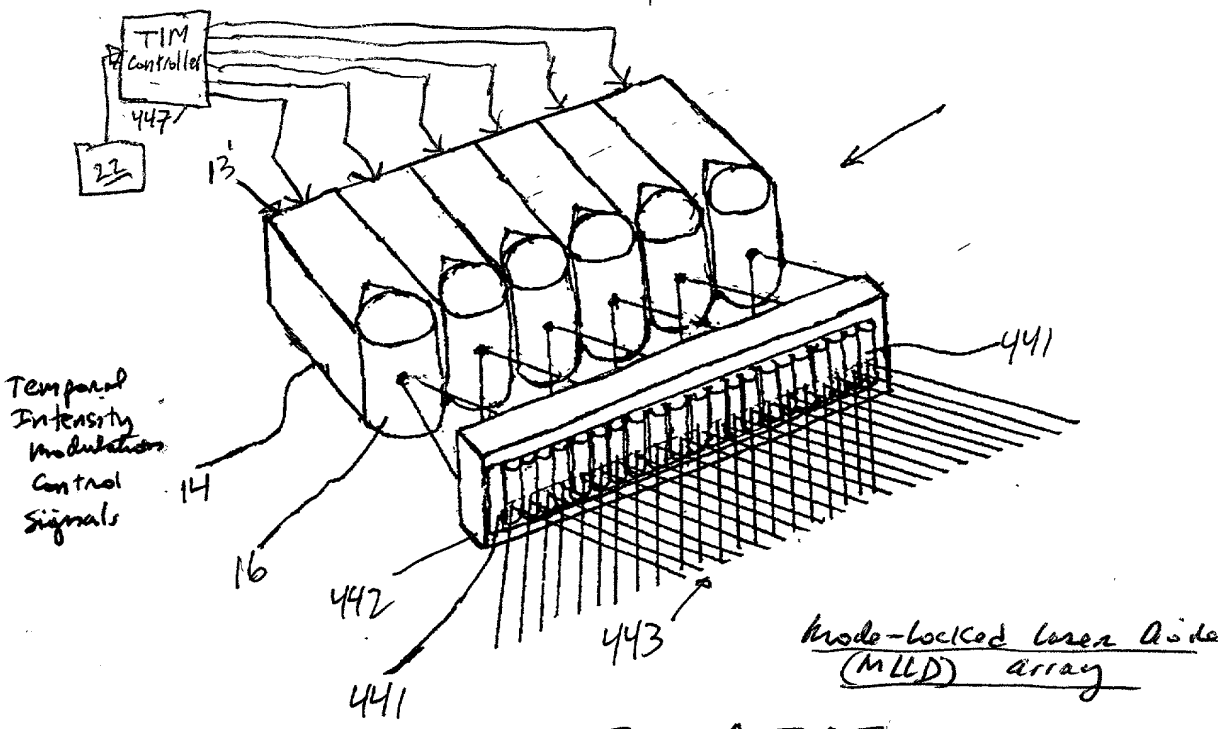


FIG. 1I15C

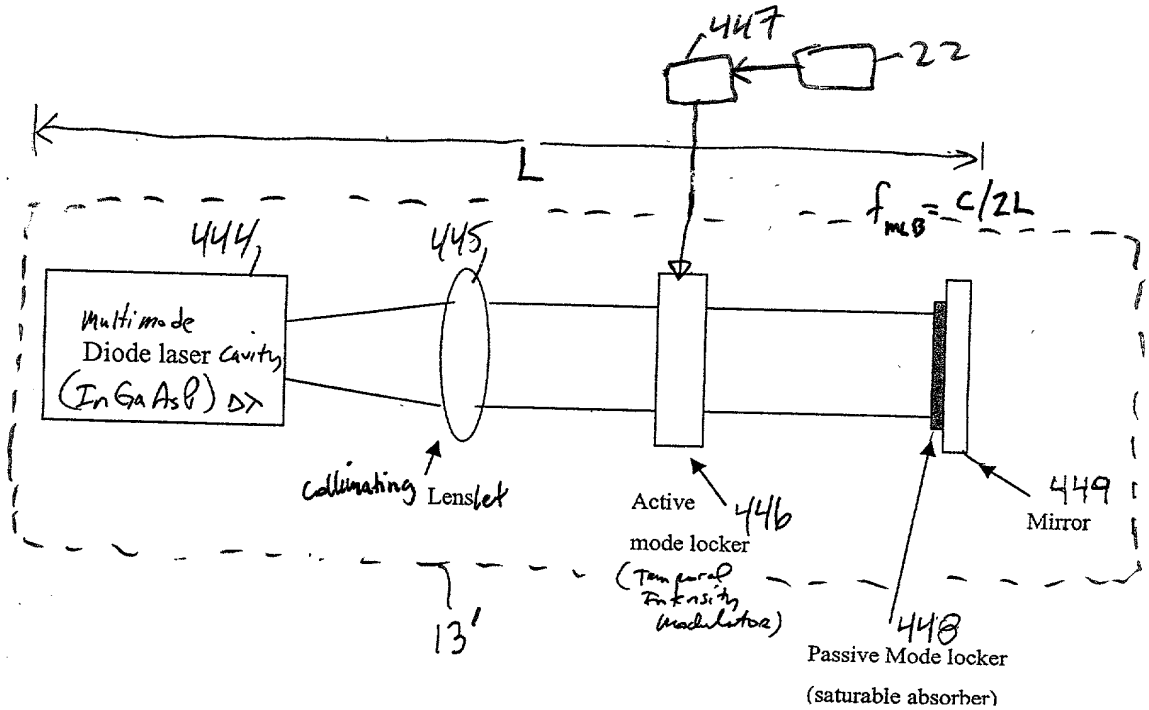


FIG. 1I15D

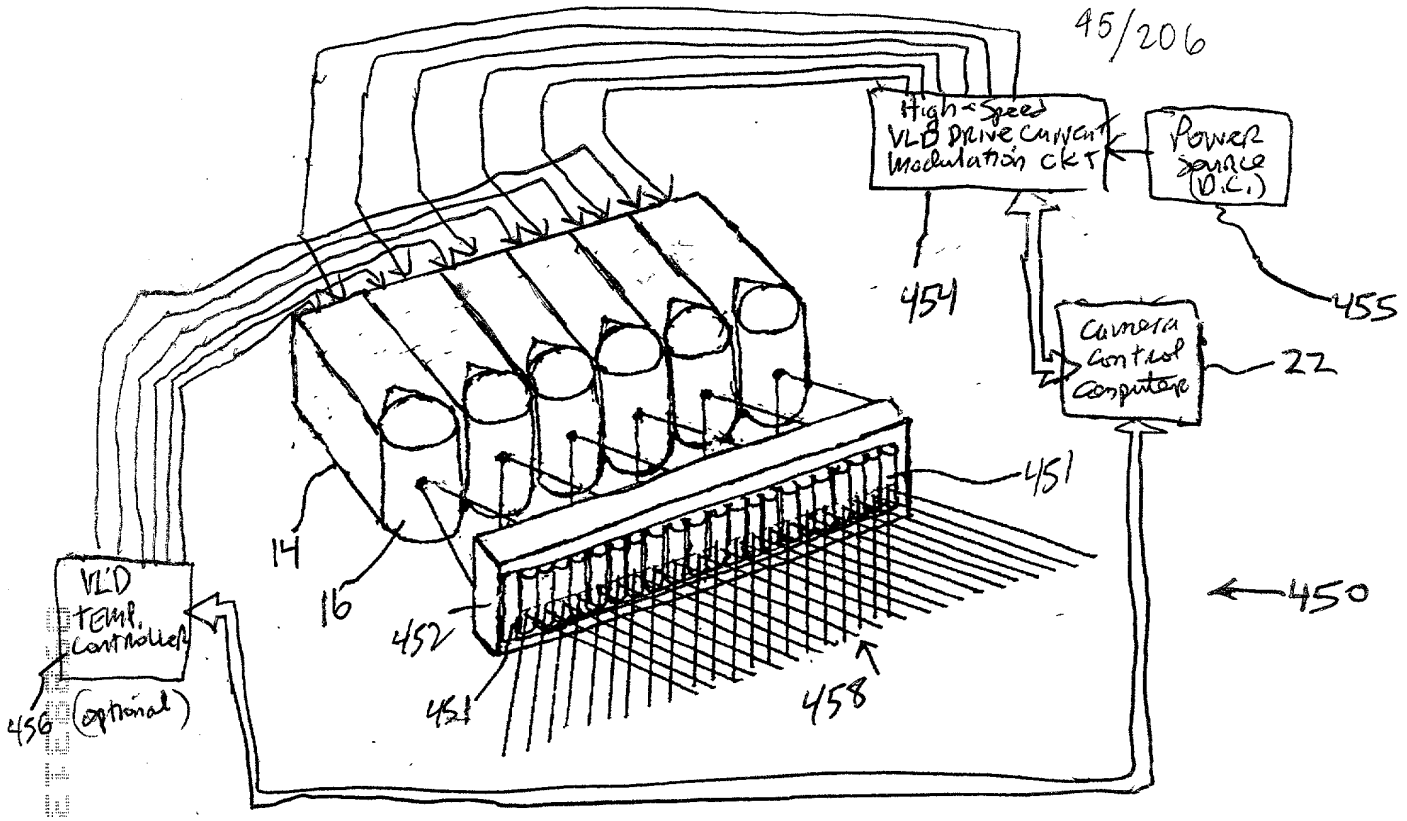


FIG. 1I16A

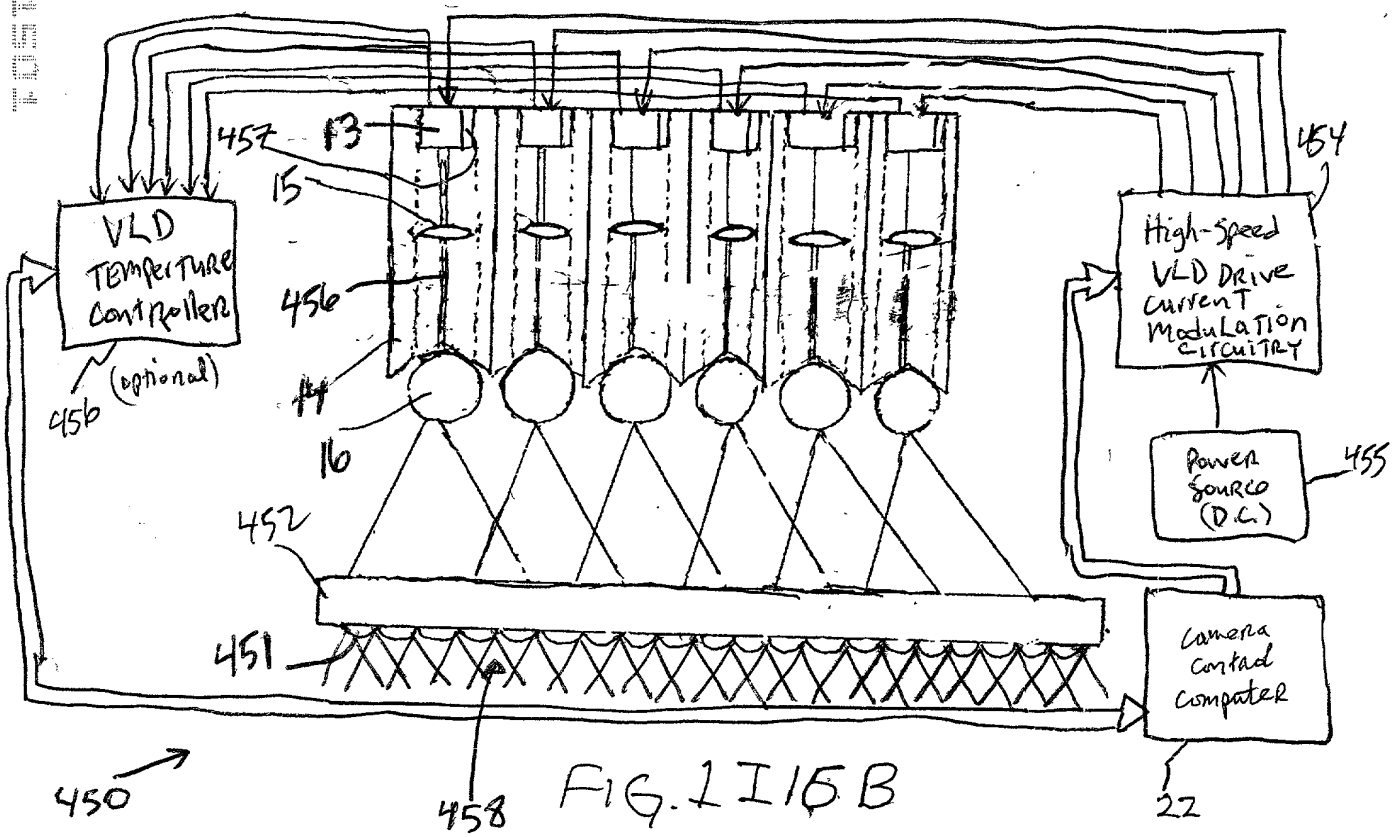
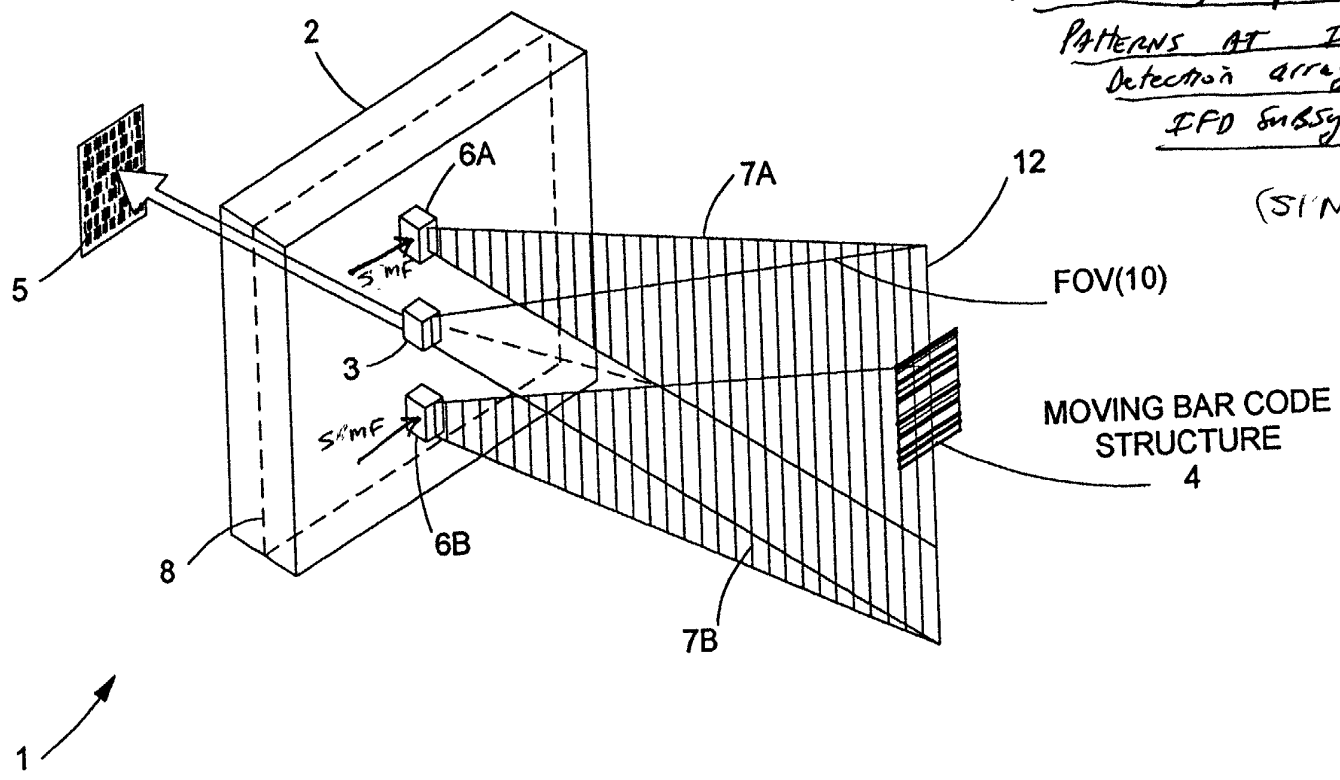


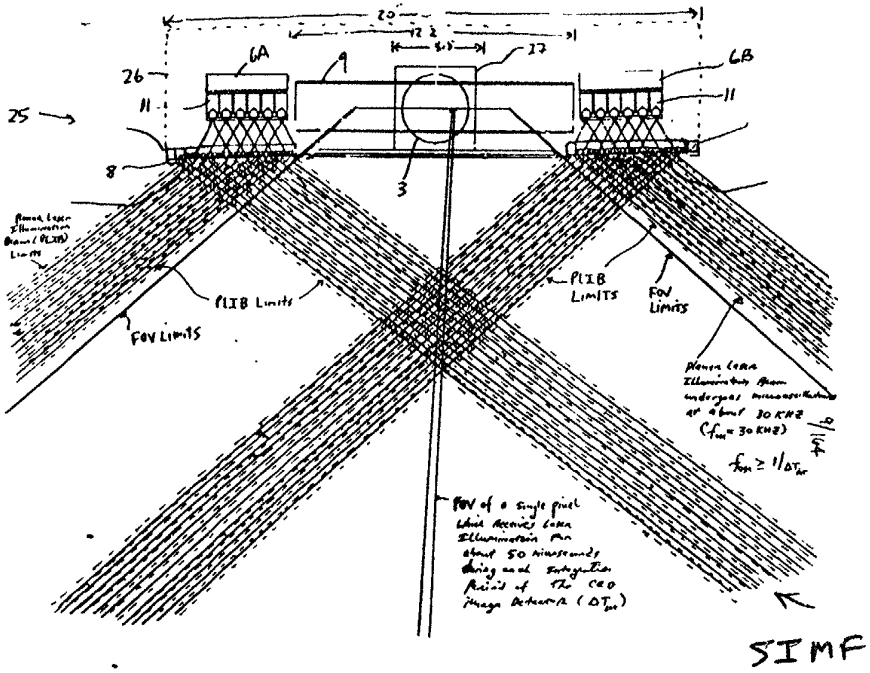
FIG. 1I16B

Third GENERALIZED METHOD of Reducing Speckle-Noise PATTERNS AT IMAGE Detection array OF the IFD SUBSystem (3)

(S'MF)



FIGIF17



Prior to object Illumination

FIG. 1I 18A

The Third Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

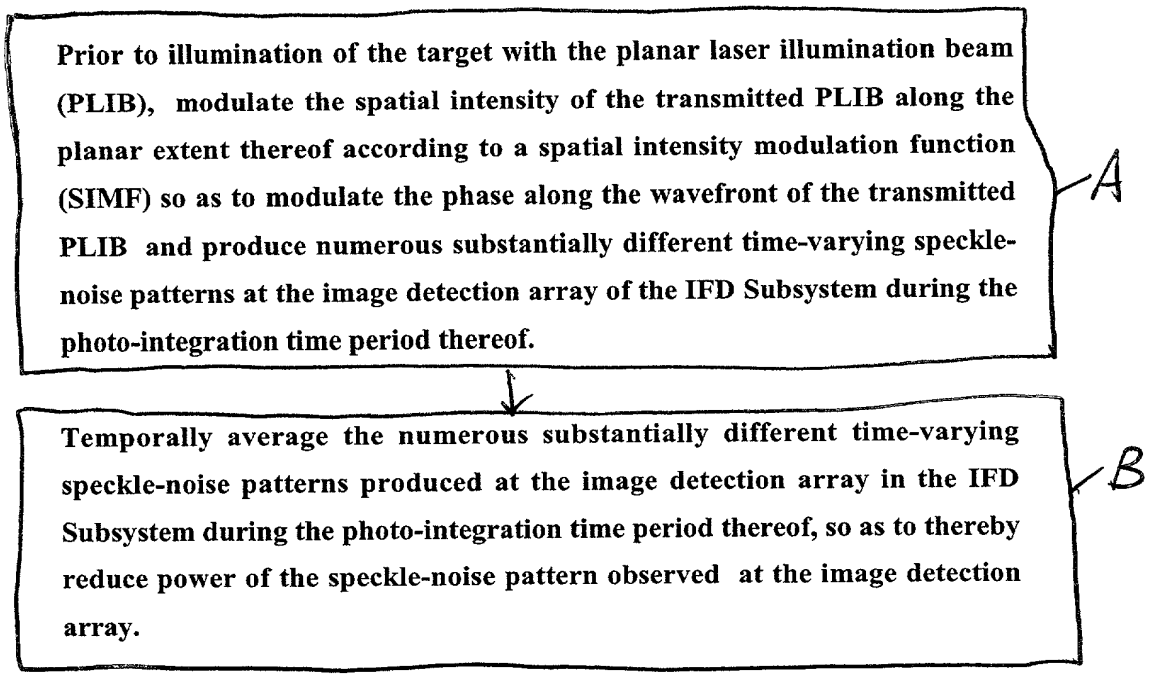


FIG. 1I18B

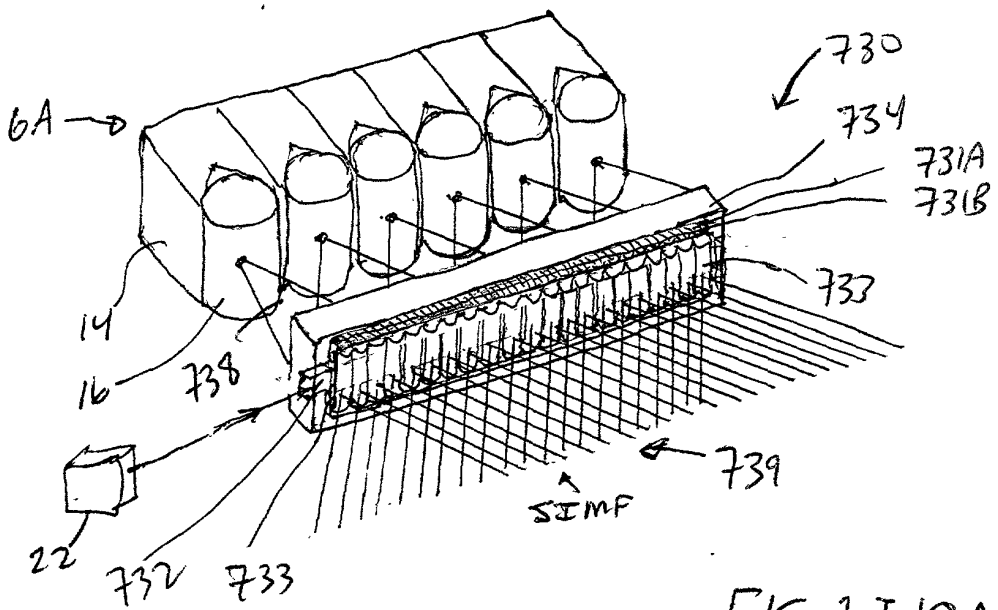


FIG. 1I19A

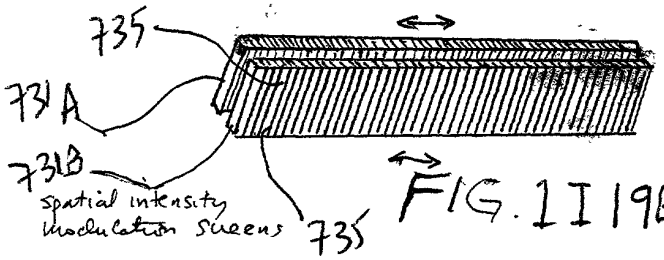


FIG. 1I19B

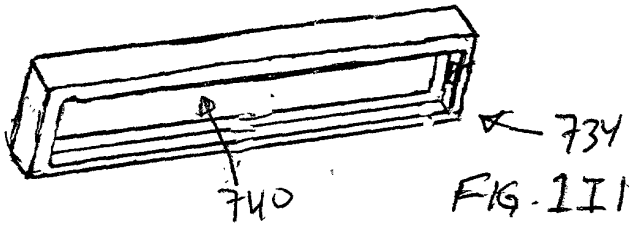


FIG. 1I19C

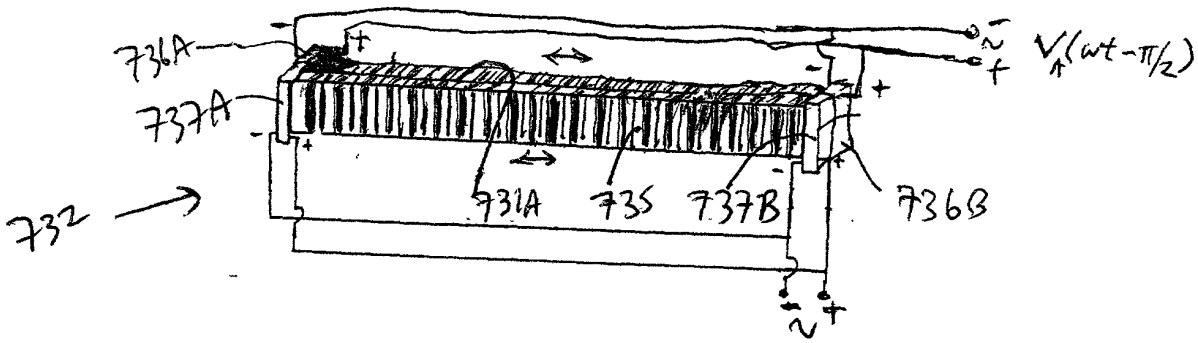


FIG. 1I19D

Fourth Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem (SIMF)

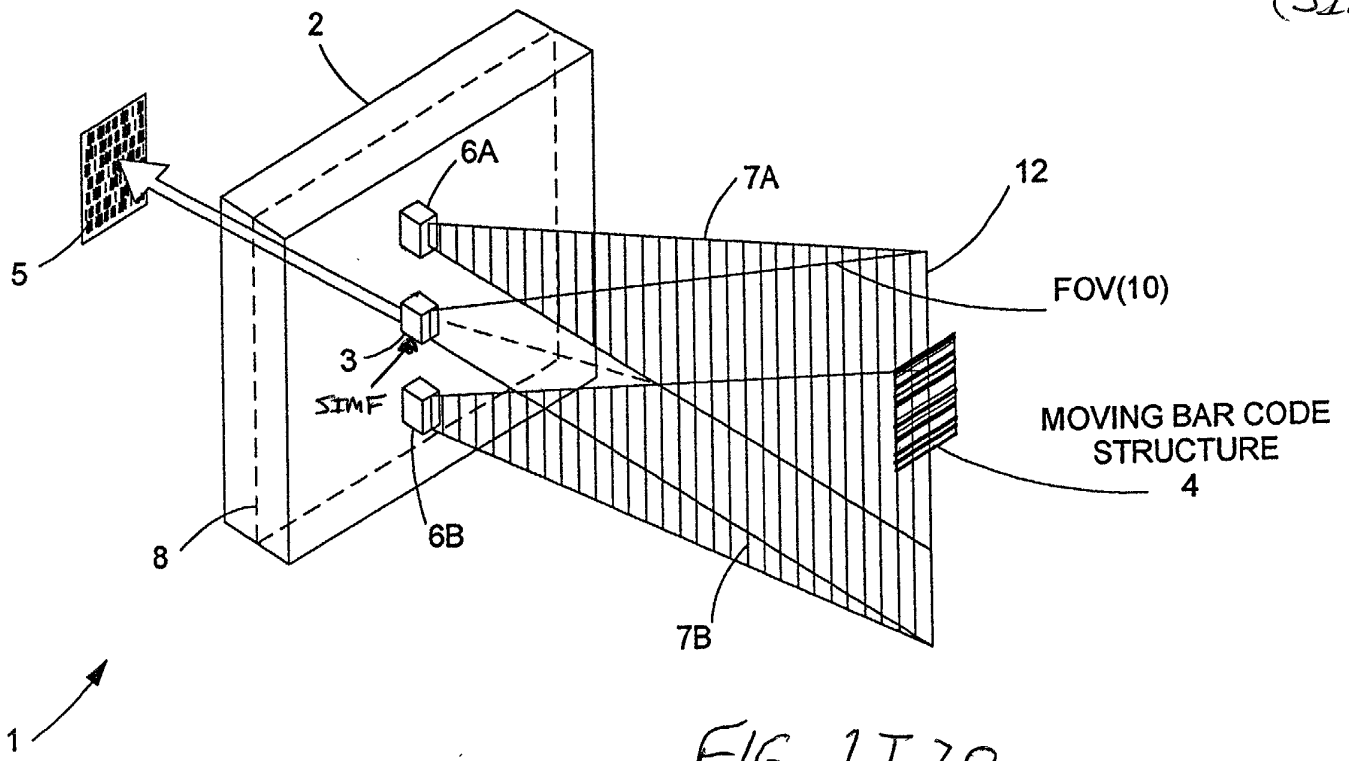


FIG. 11.20

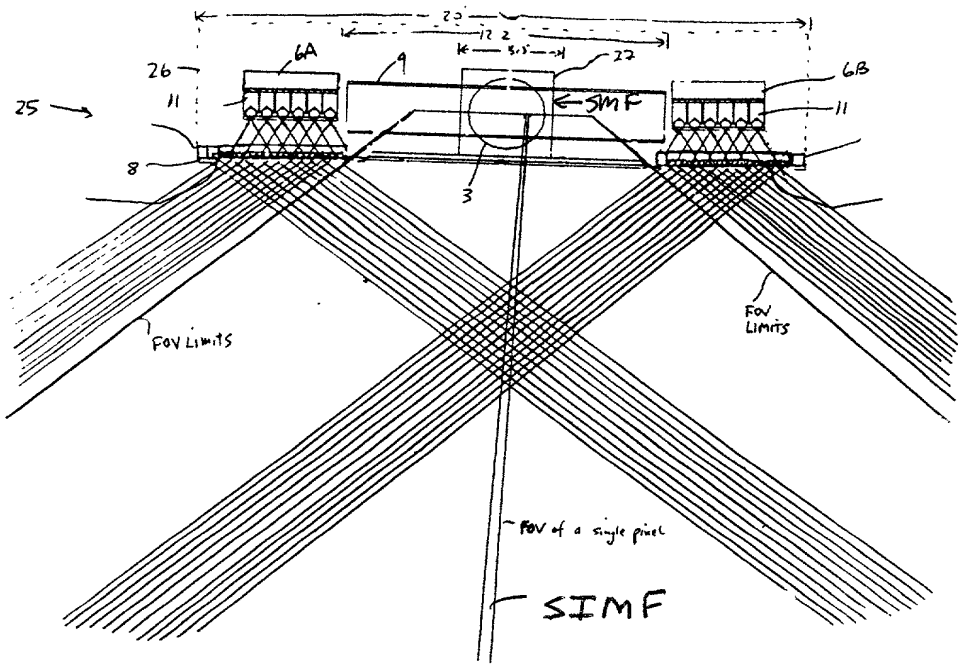

23
12.2
5.5
6A
9
27
6B
26
11
25
SMF
11
8
3
FoV Limits
FoV Limits
FoV of a single pixel
SIMF

FIG. II 21A

The ~~Fourth~~ Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

After illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to modulate the phase along the wavefront of the received PLIB and produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof. — A

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array. — B

FIG. 11 21B

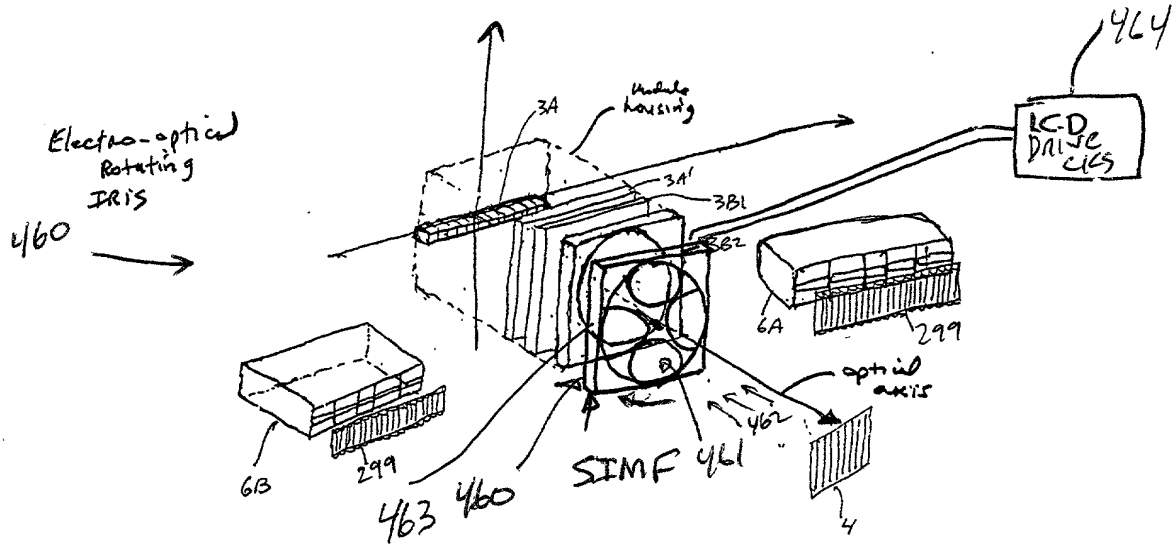


FIG. 1I22A

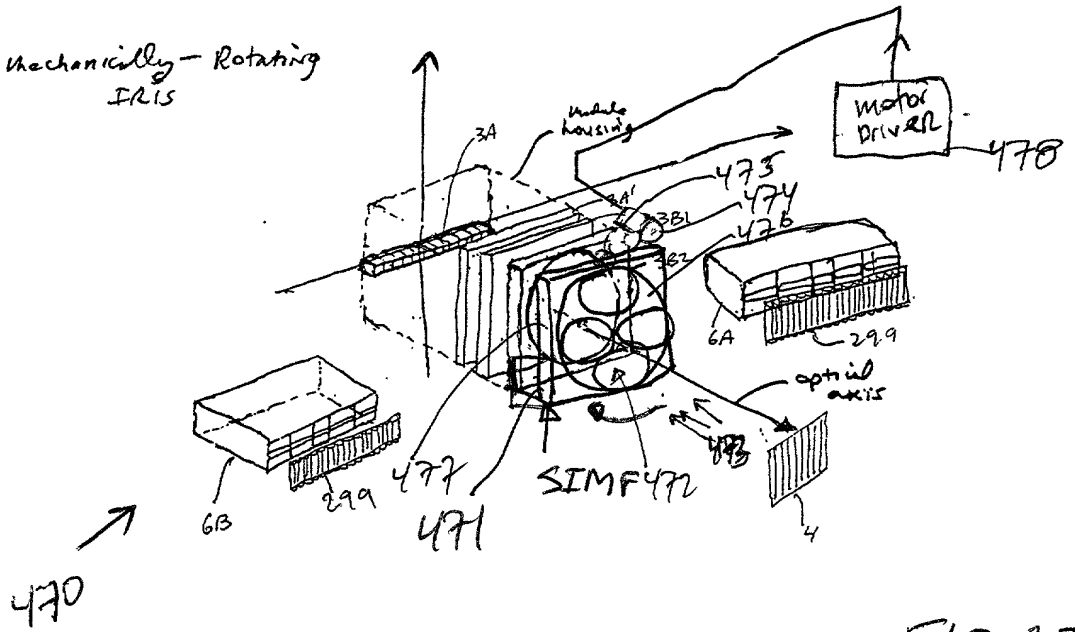


FIG. 1I22B

Fourth Generalized Method of Reducing Speckle-Noise Patterns at Image Detection Array of the IFD Subsystem

(TIMF)

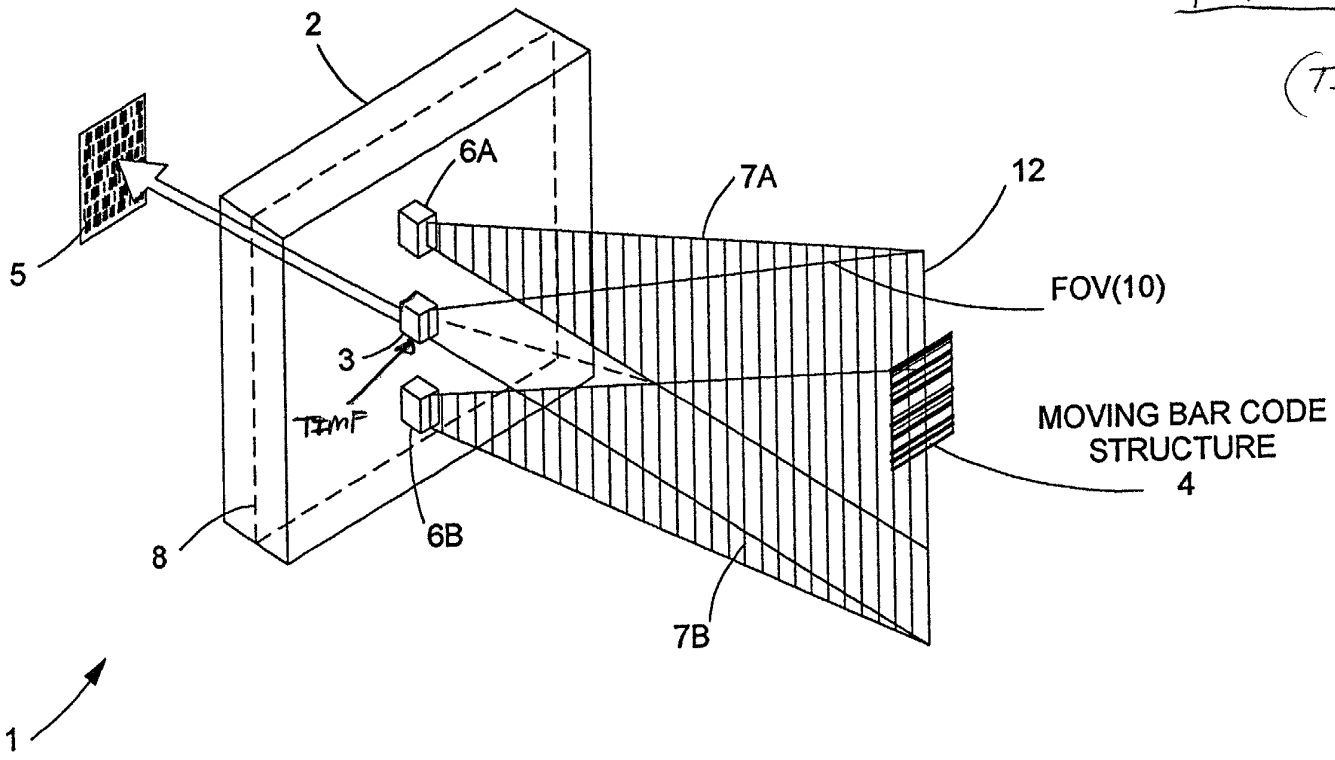


FIG. 1I23

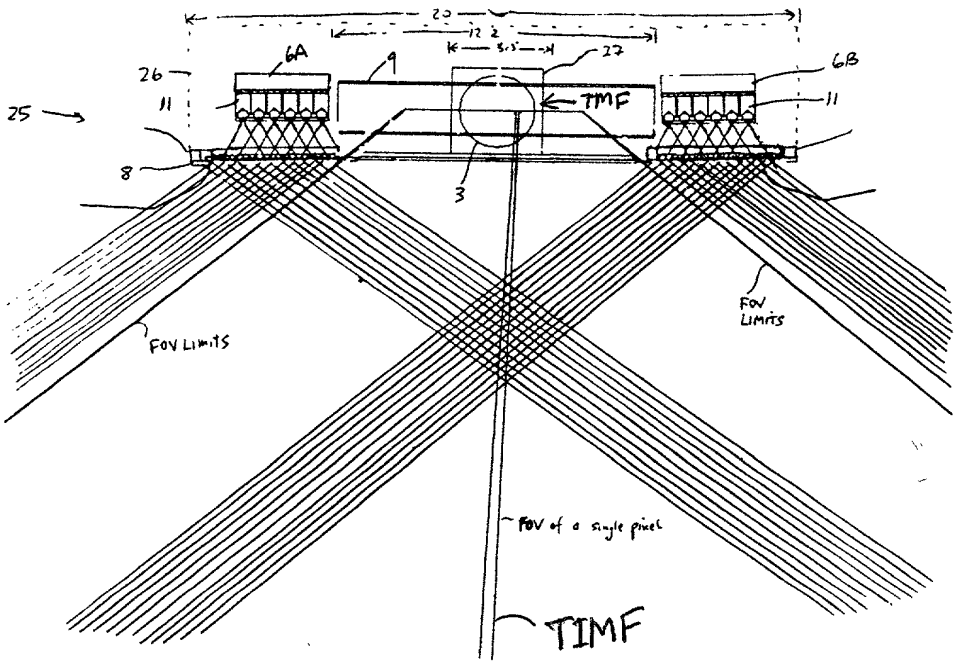

20
12.2
6A
9
22
6B
26
11
TMF
11
25
8
3
FOV LIMITS
FOV LIMITS
FOV of a single pixel
TIMF

FIG. 1I 24A

The Fifth Generalized Speckle-Noise Pattern Reduction Method Of The Present Invention

After illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a temporal intensity modulation function (TIMF) so as to modulate the phase along the wavefront of the received PLIB and produce many substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof. — A

↓

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array. — B

FIG. 11 24B

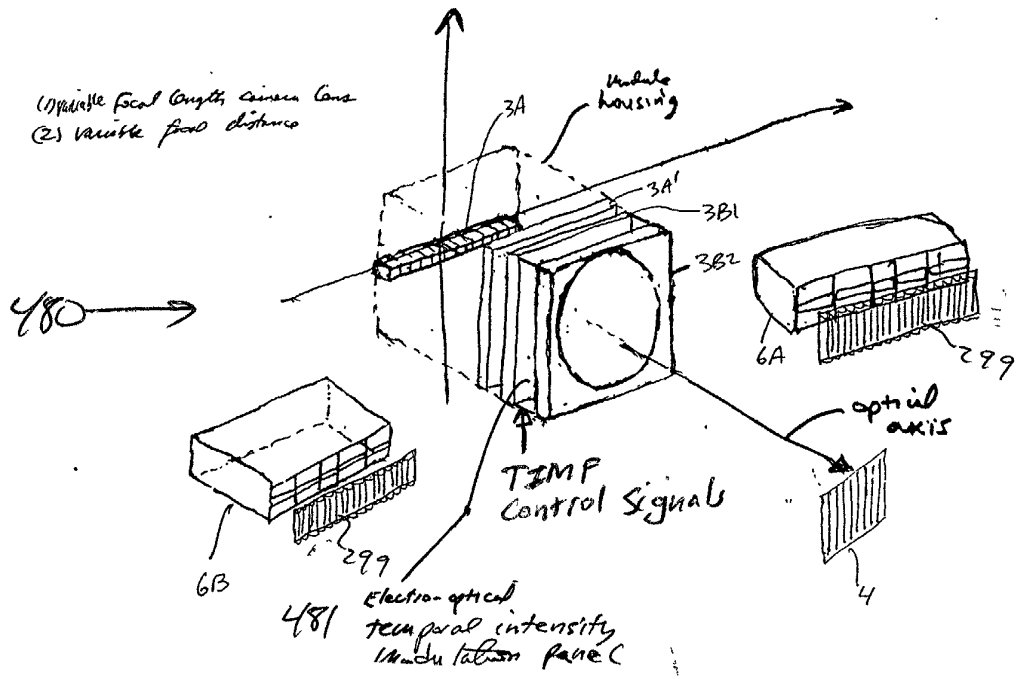

(1) Variable focal length camera lens
(2) variable focal distance
3A
Module housing
3A'
3B1
3B2
480
6A
299
optical axis
TIMP Control Signals
6B
299
481
Electro-optical temporal intensity modulation panel
4

FIG. 1I 25

Fixed focal length lens cases

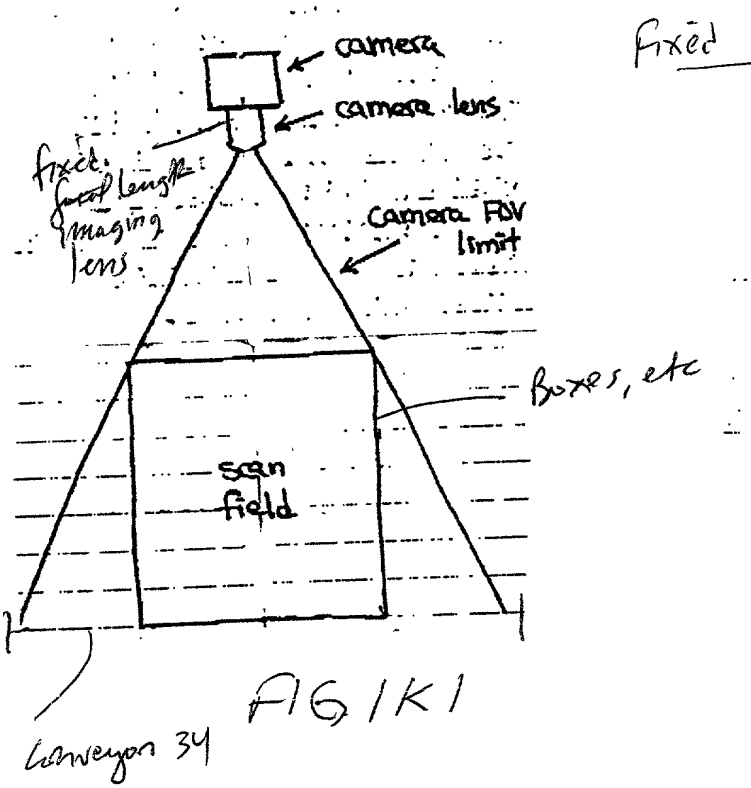


FIG 1K1

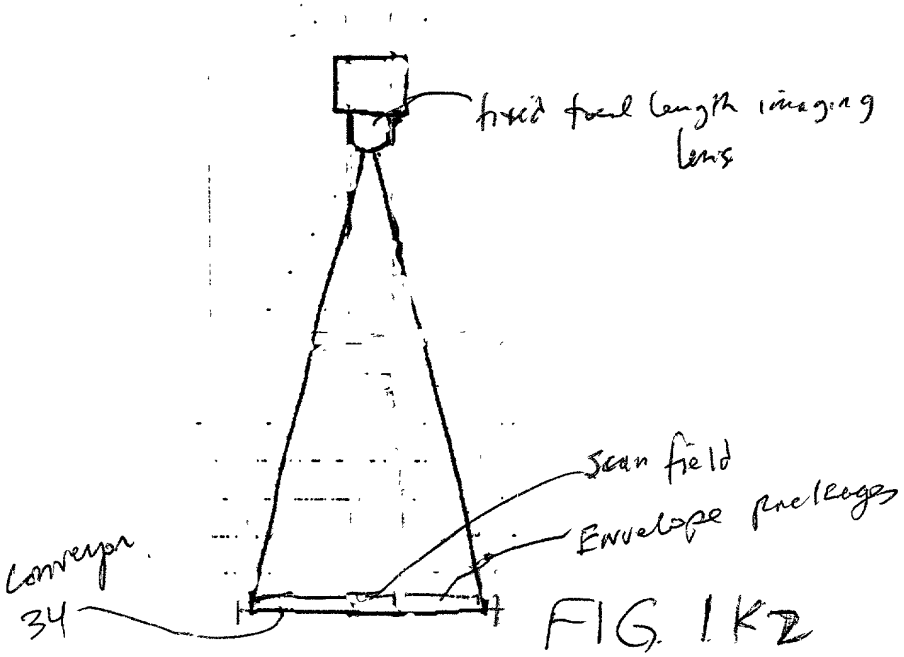


FIG. 1K2

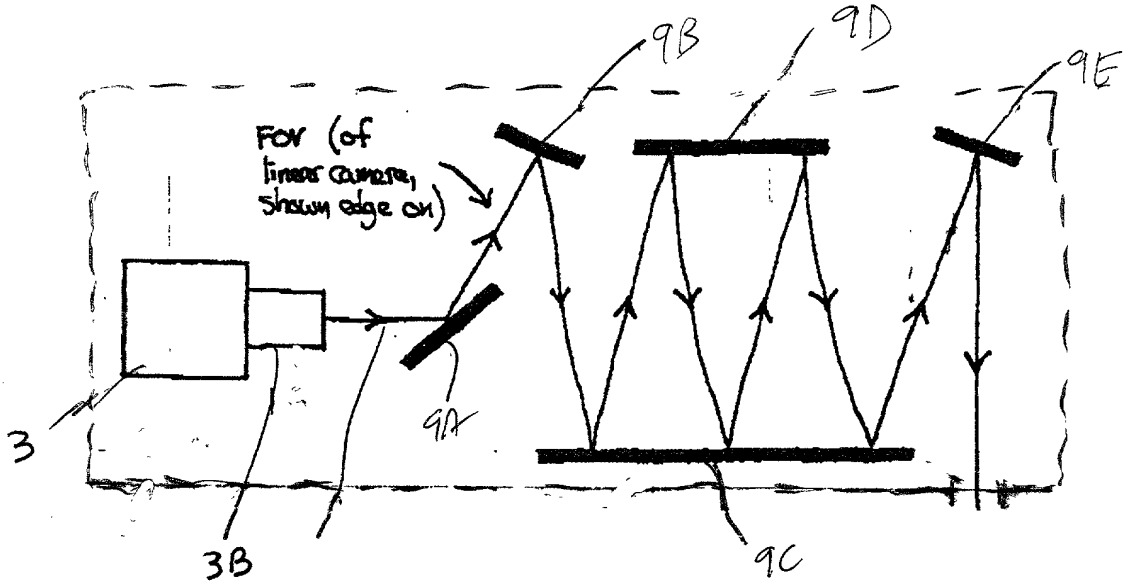


FIG. 1L1

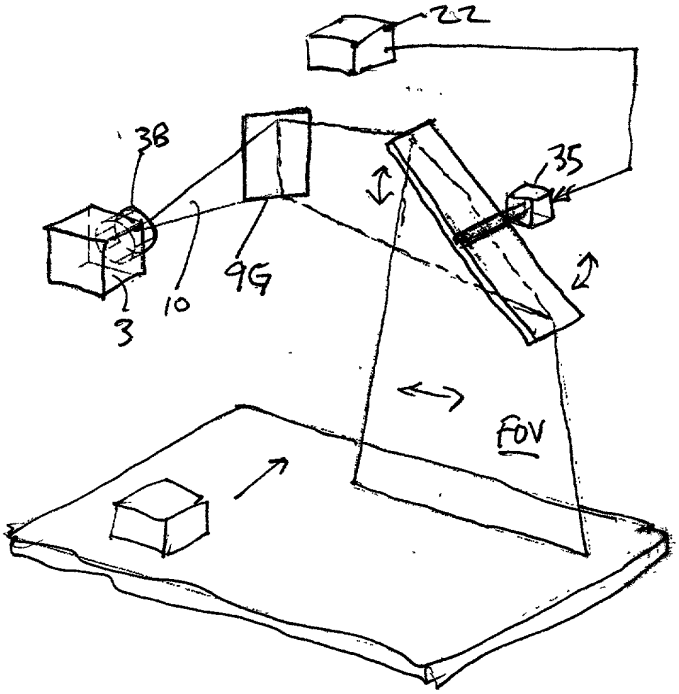


FIG. 1L2

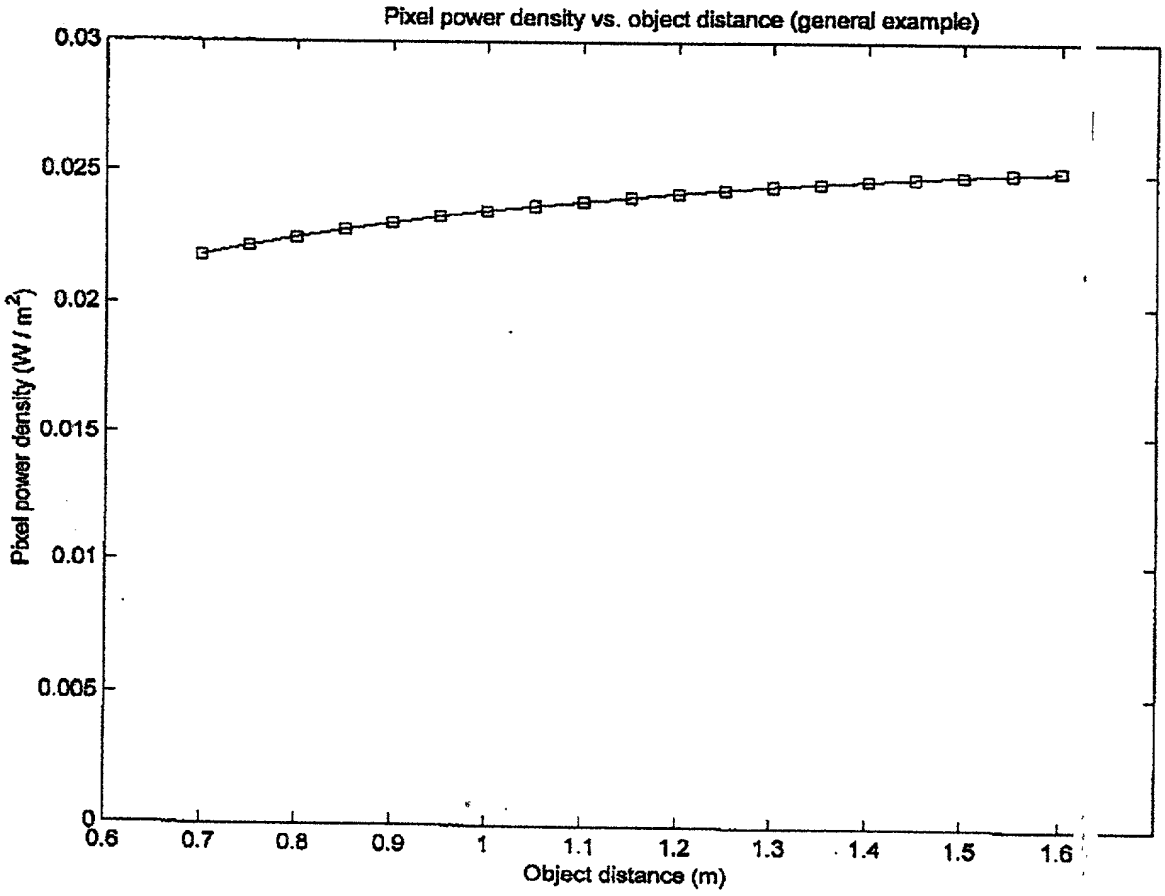

Pixel power density vs. object distance (general example)
Pixel power density (W / m2)
Object distance (m)
0.03
0.025
0.02
0.015
0.01
0.005
0
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG-1M1

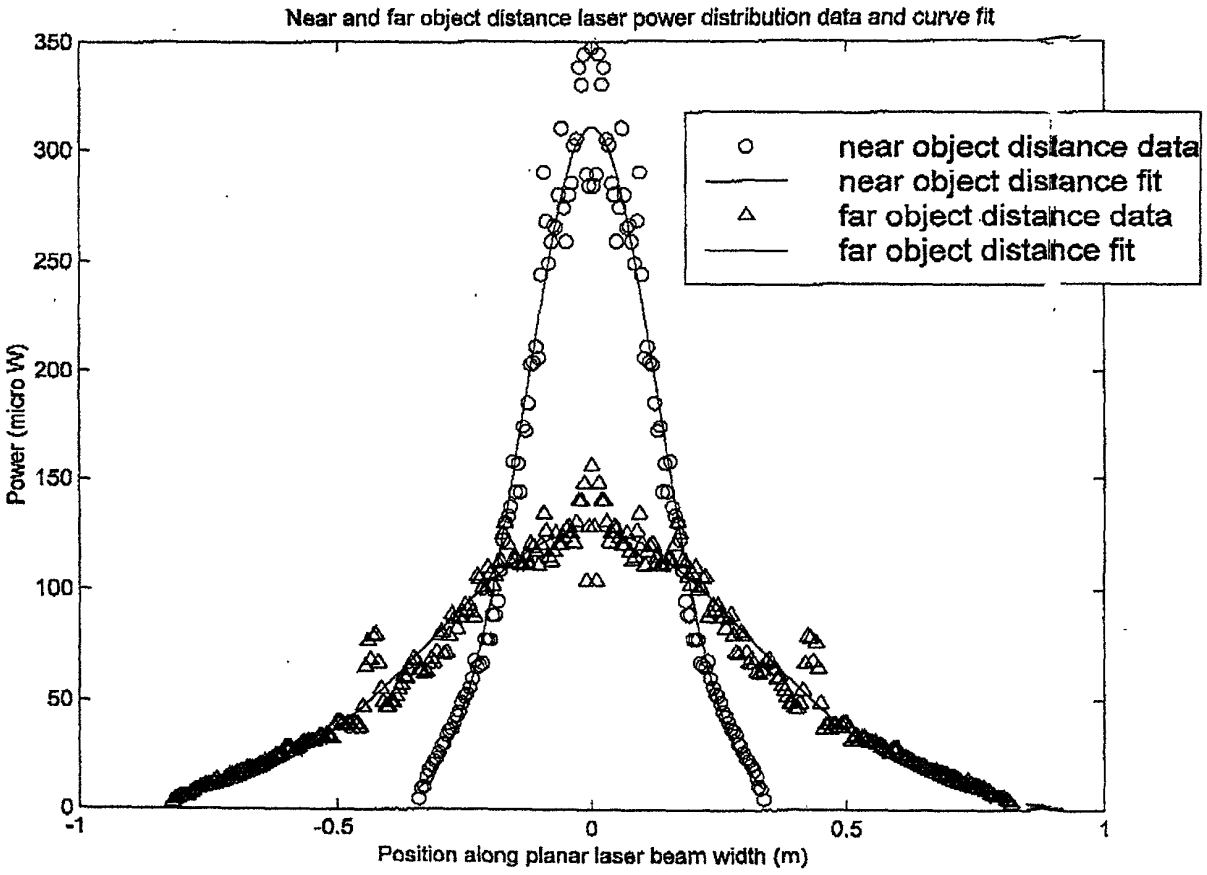

Near and far object distance laser power distribution data and curve fit
Power (micro W)
Position along planar laser beam width (m)
near object distance data
near object distance fit
far object distance data
far object distance fit
350
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1

FIG. 1M2

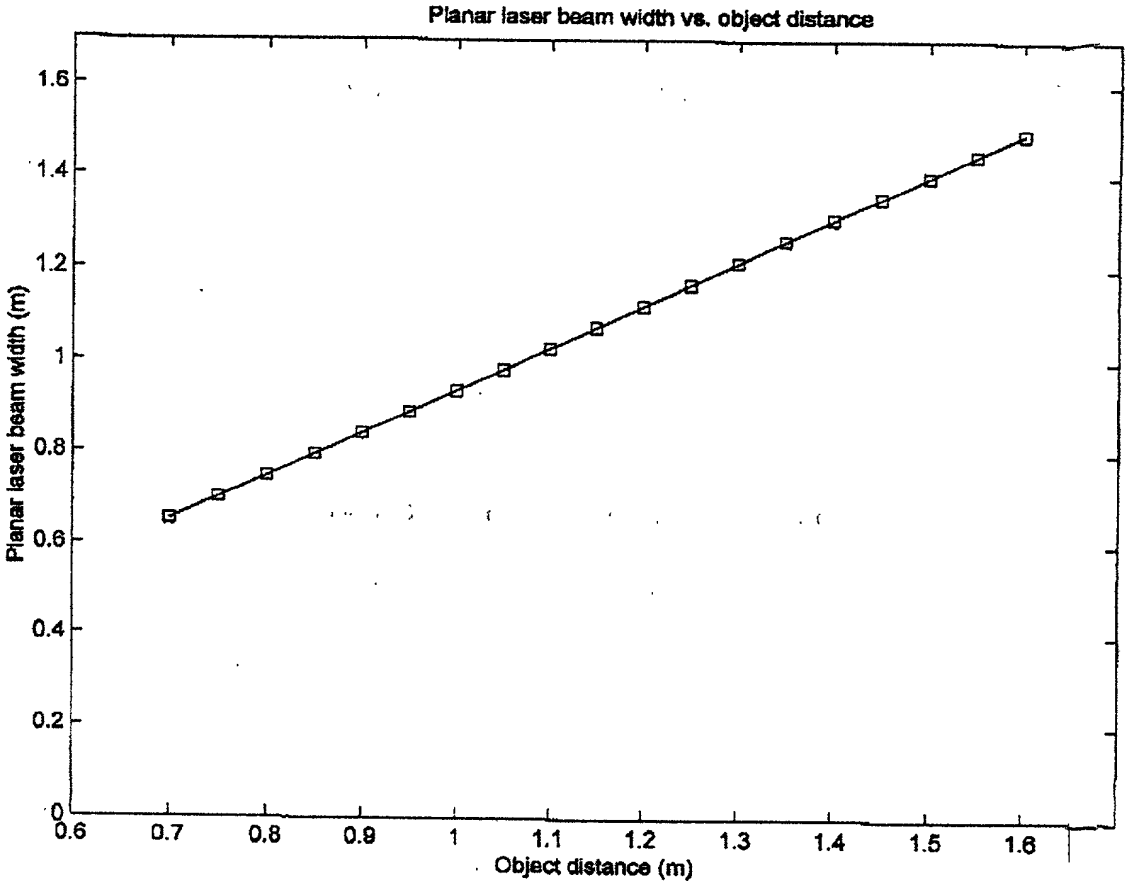

Planar laser beam width vs. object distance
Planar laser beam width (m)
Object distance (m)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG. 1M3

Figure 4: Planar laser beam height vs. object distance (far object distance focus)

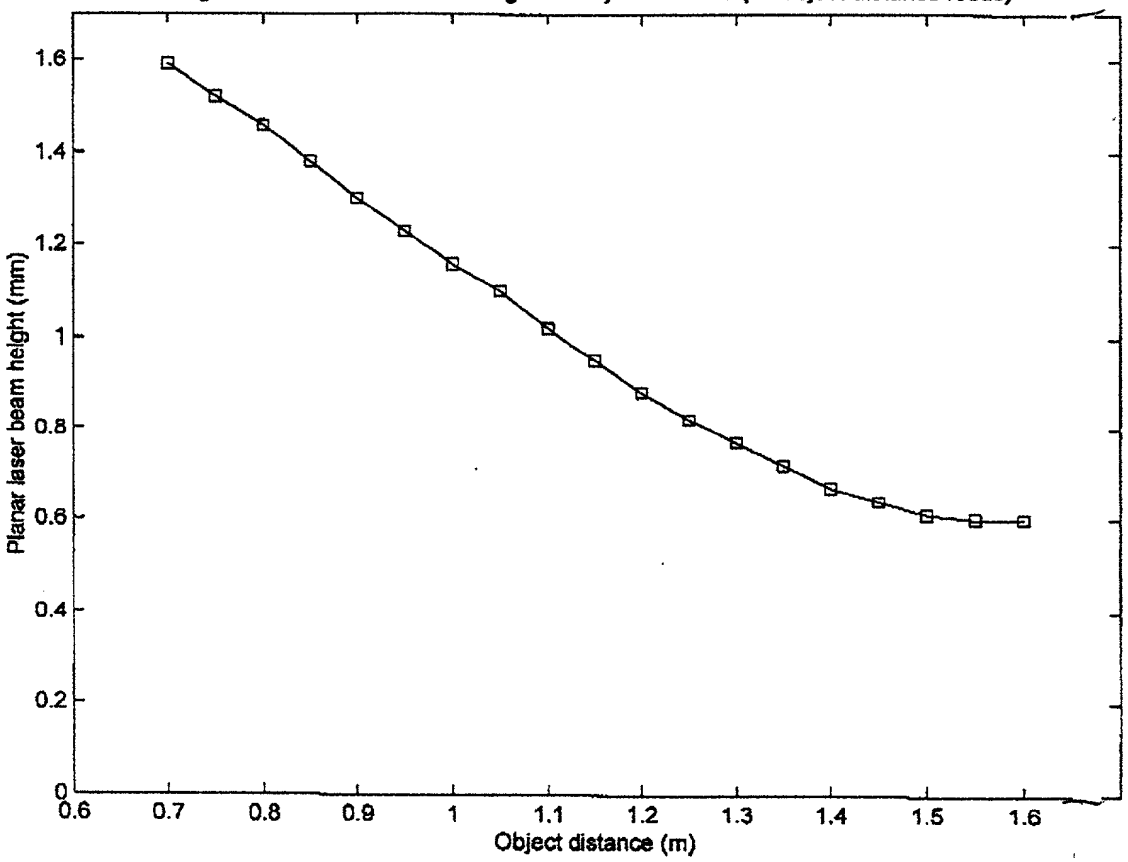


FIG. 14

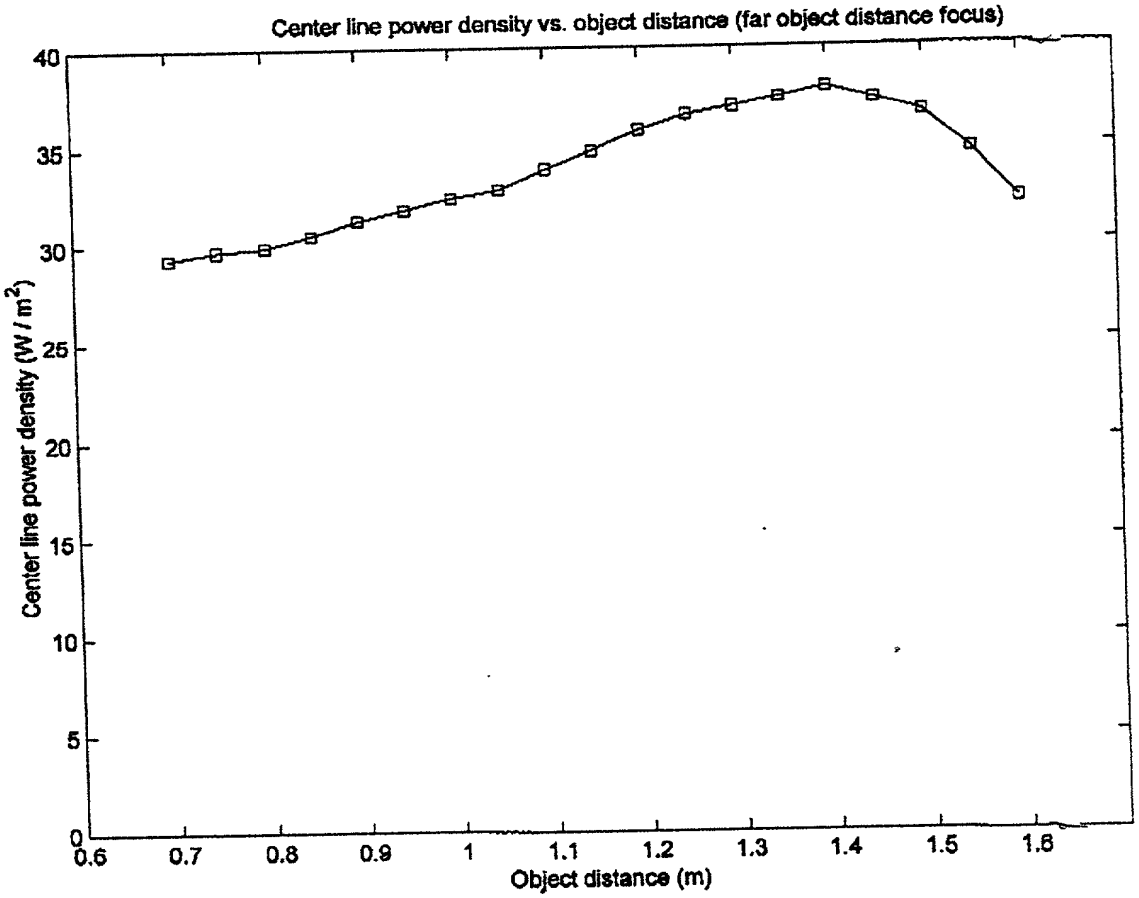

Center line power density vs. object distance (far object distance focus)
Center line power density (W / m2)
Object distance (m)
0
5
10
15
20
25
30
35
40
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6

FIG. 1N

Figure 6: Pixel power densities vs. object distance

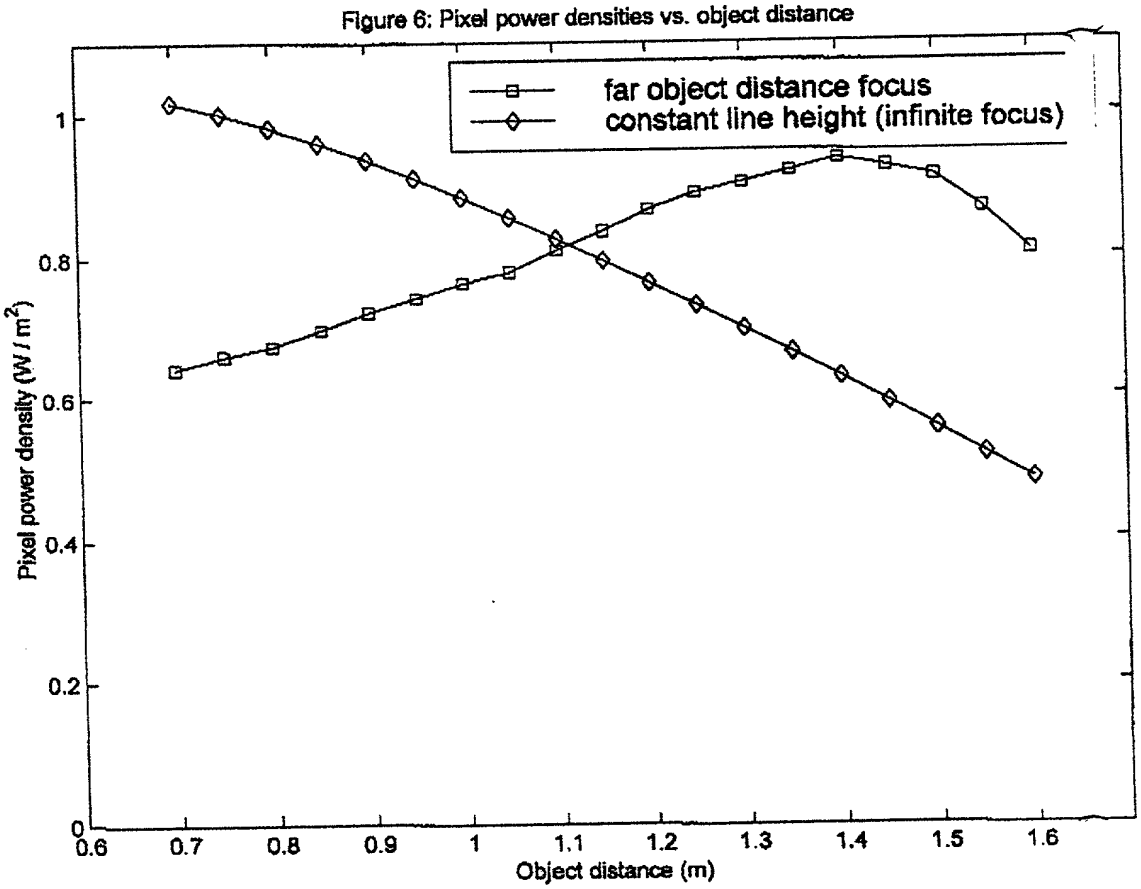


FIG. 10

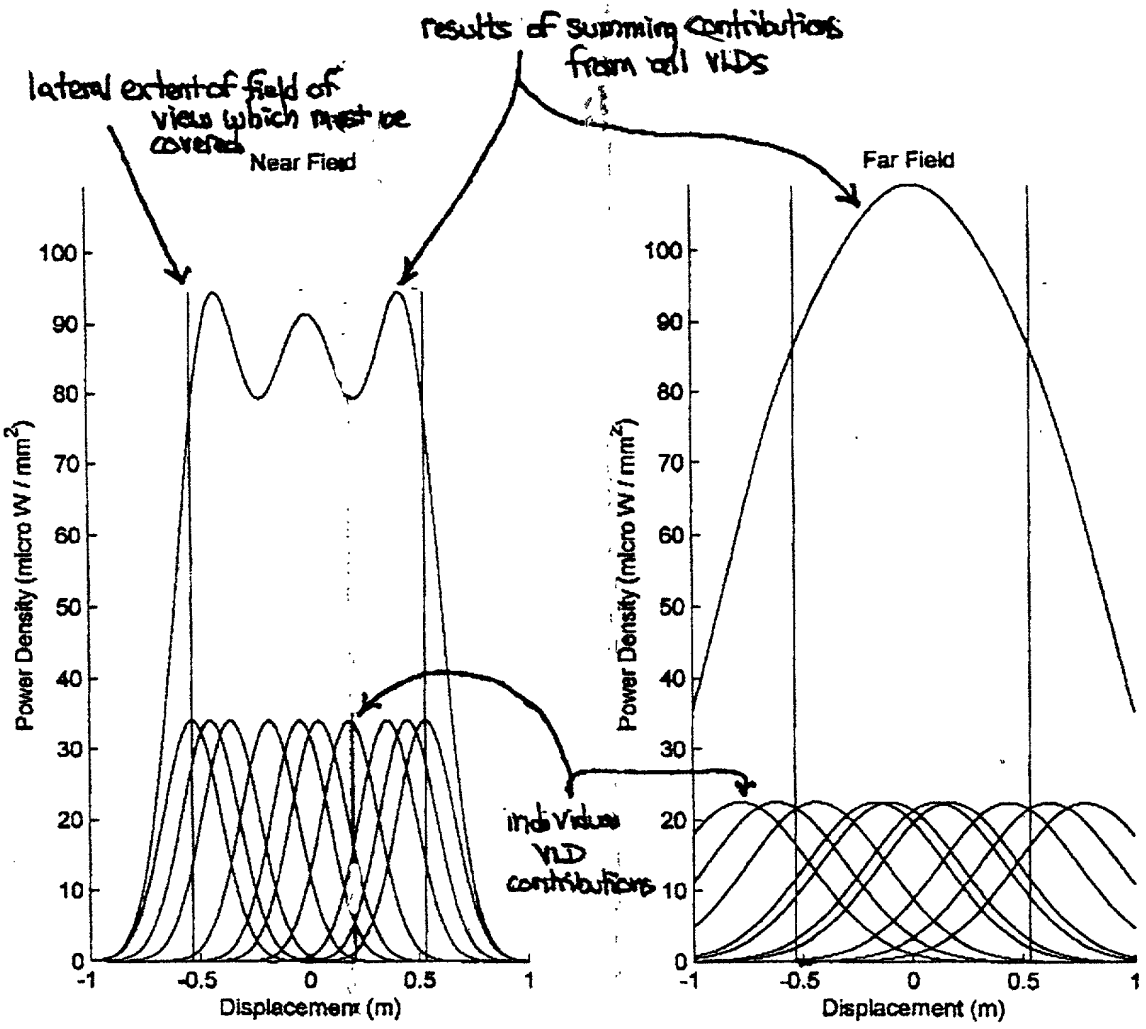


FIG. 1P1

FIG. 1P2

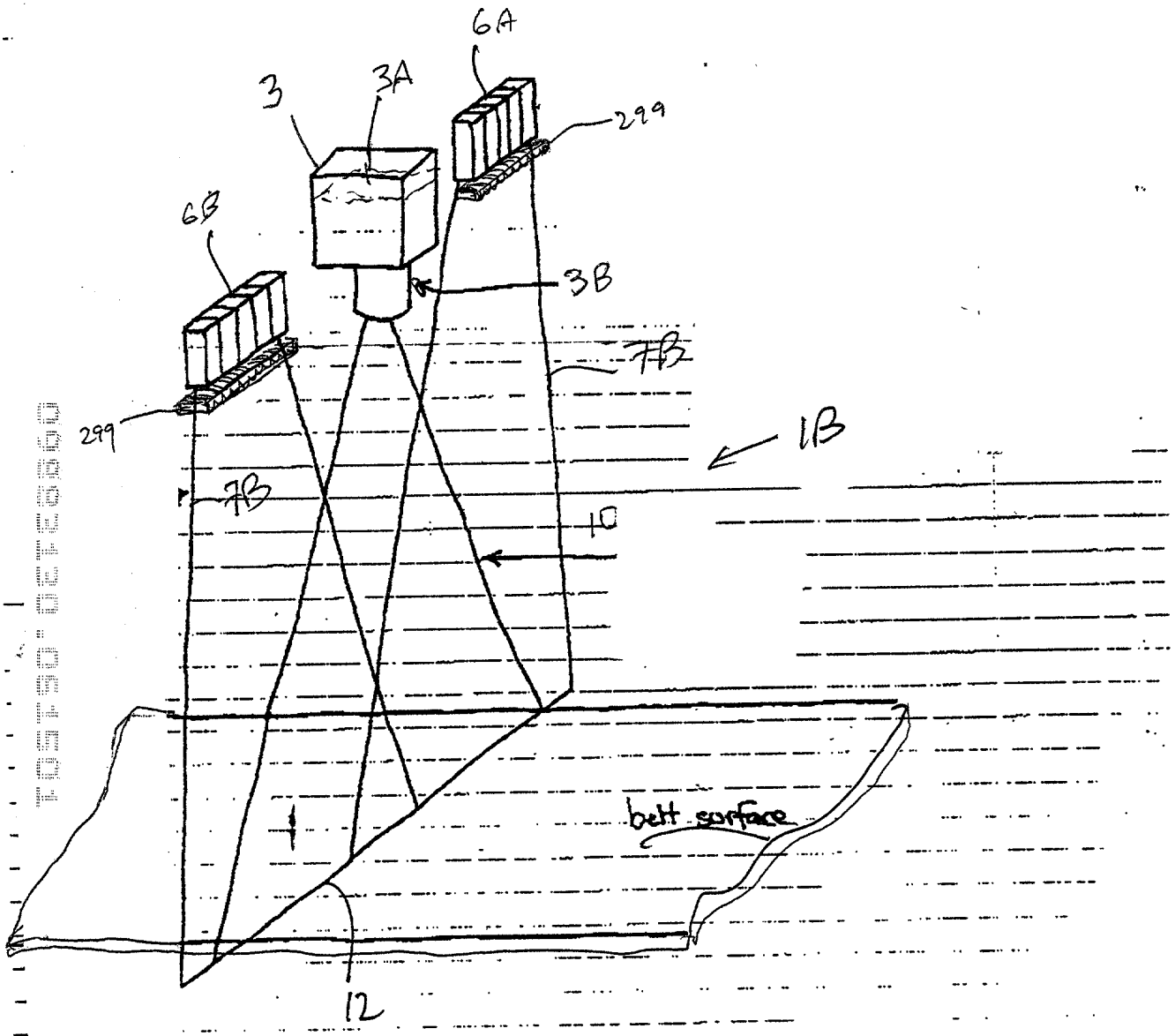


FIG. 1Q1

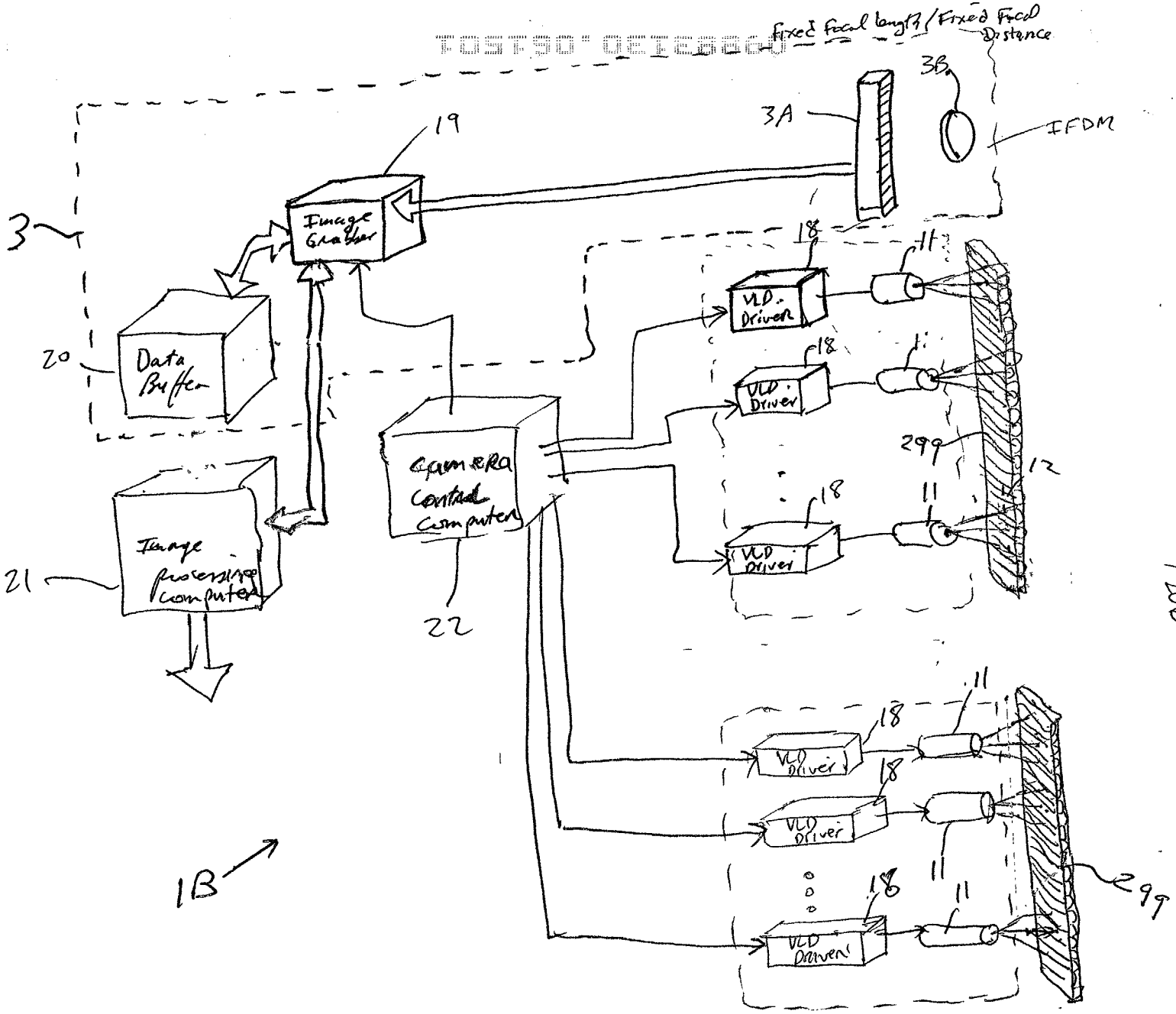


FIG. 1Q2

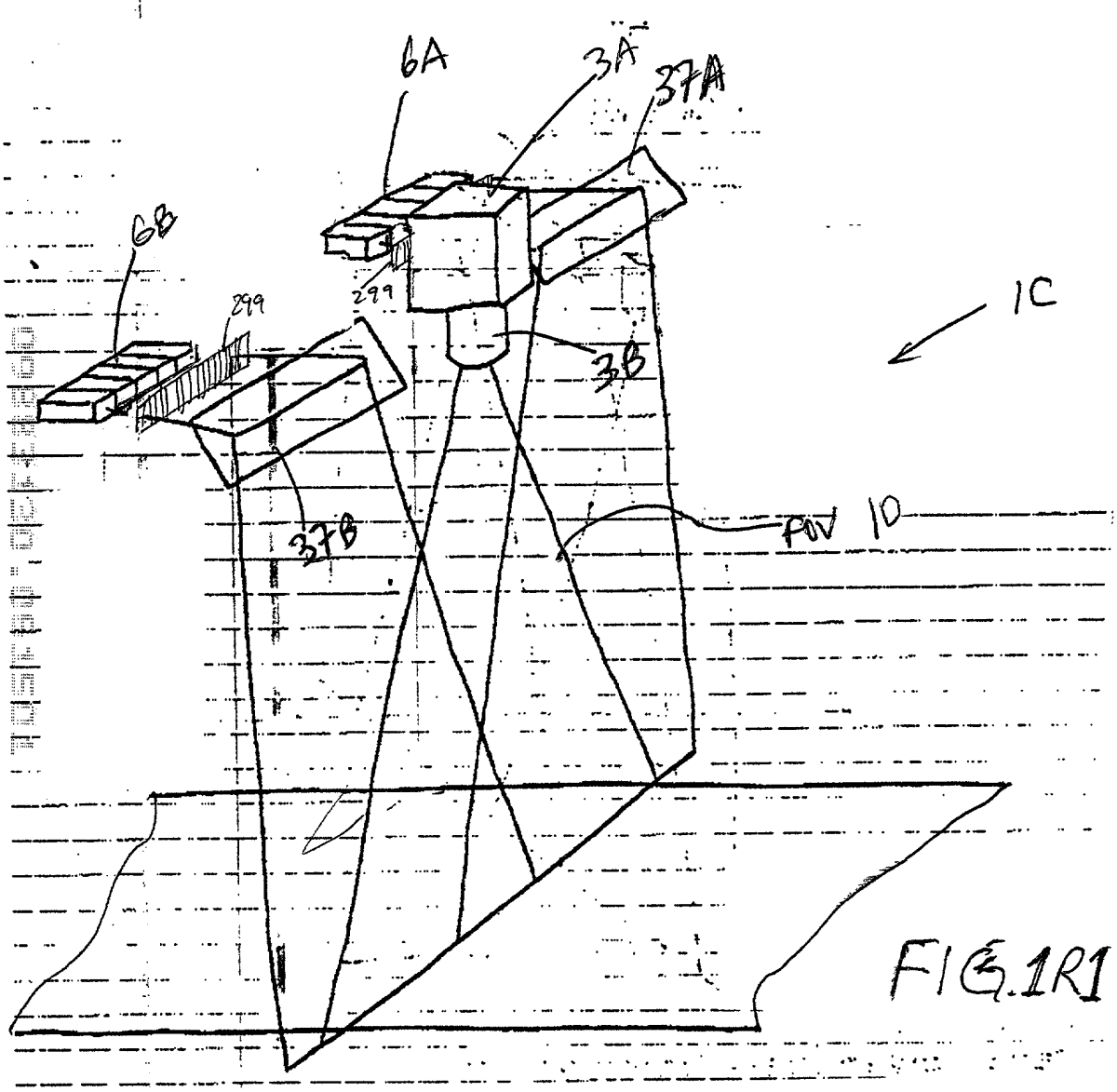


FIG.1R1

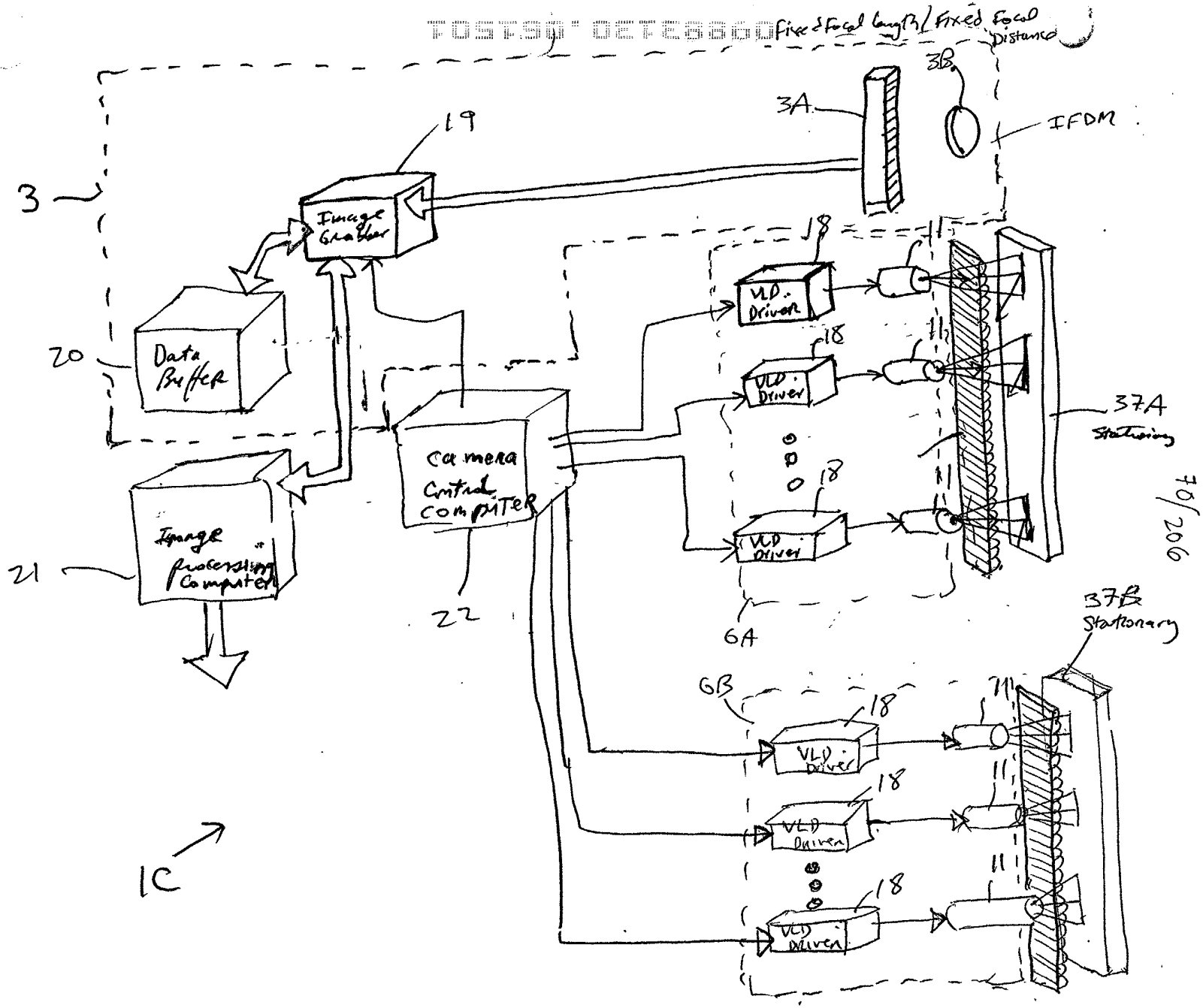

3
19
Image Grabber
3A
3B
IFDM
20
Data Buffer
18
VLD Driver
18
VLD Driver
18
VLD Driver
37A
Stationary
Camera Control Computer
21
Image processing Computer
22
6A
37B
Stationary
6B
18
VLD Driver
18
VLD Driver
18
VLD Driver
1C

FIG. 1R2

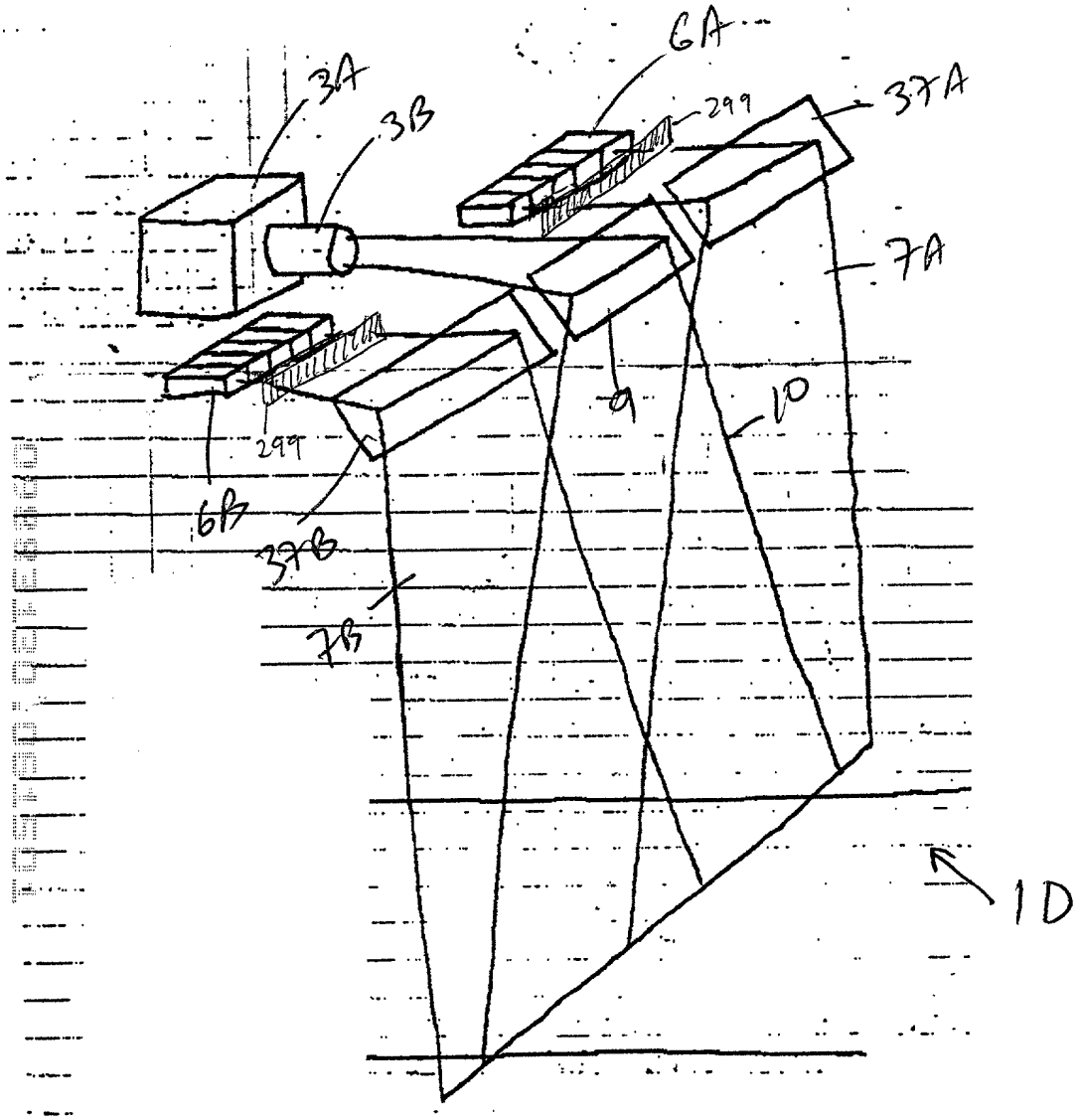


FIG. 1S1

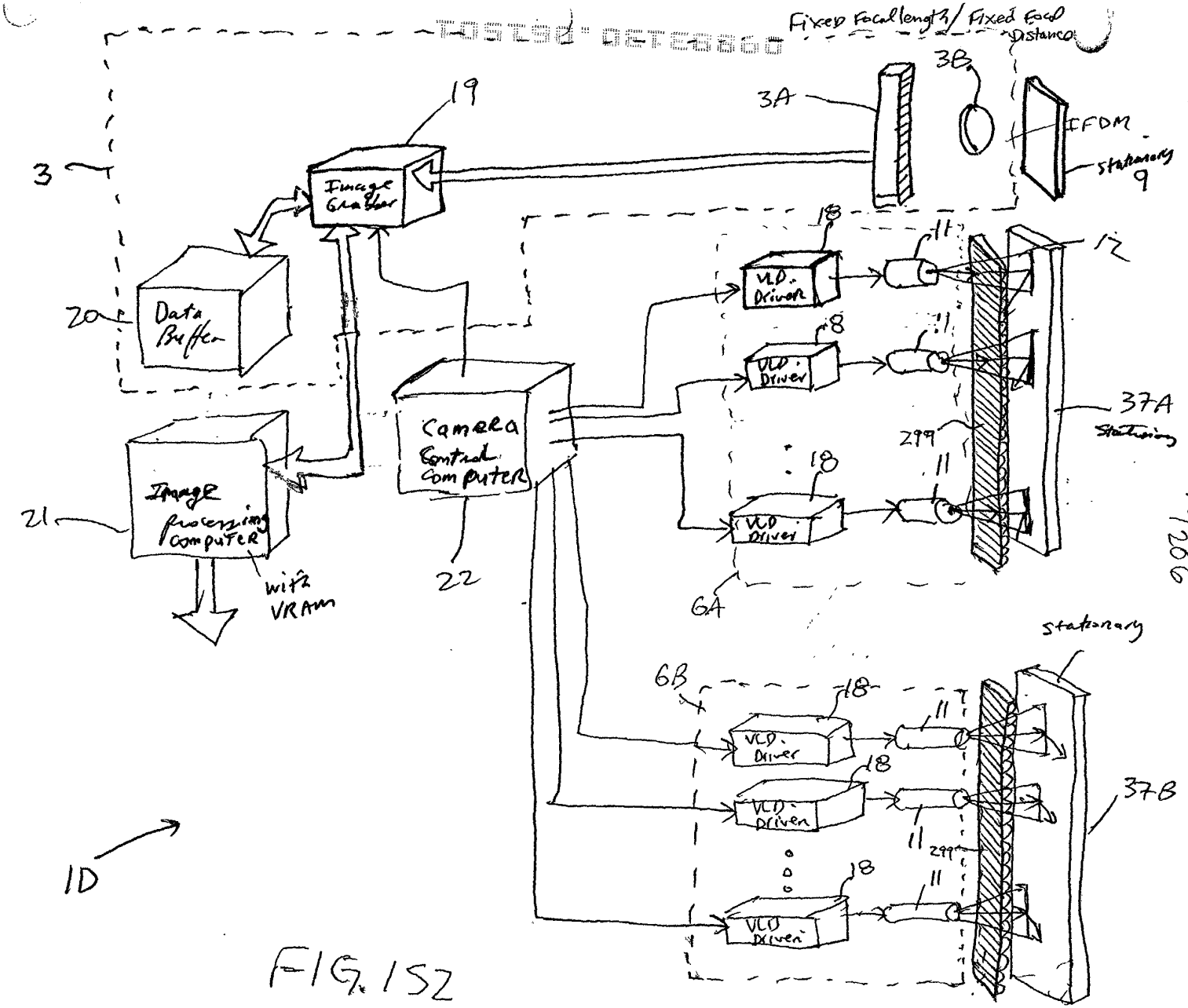
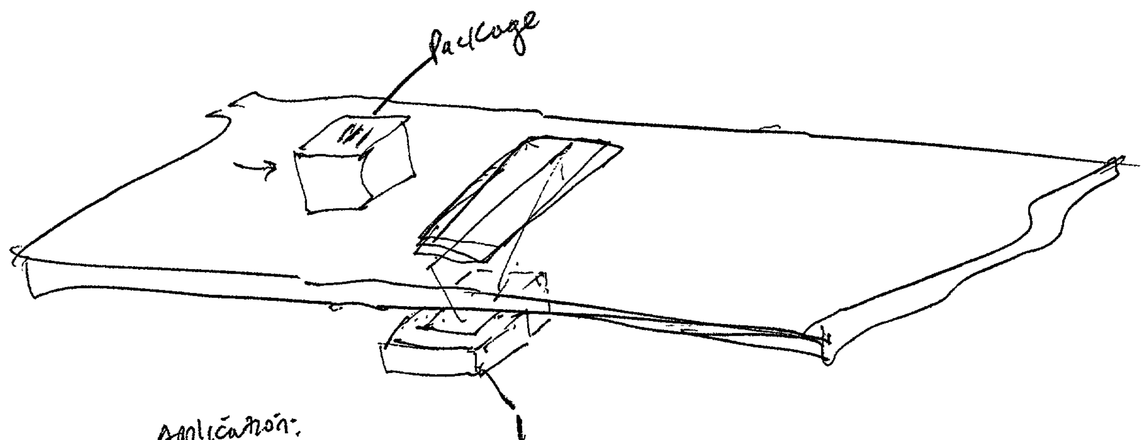

Fixed Focal length/ Fixed Focal Distance
3B
3A
IFDM
stationary
9
19
3
Image Grabber
18
11
12
VLD Driver
20
Data Buffer
8
37A
299
Camera Control Computer
18
Image processing computer
21
with VRAM
22
6A
72/206
stationary
6B
18
37B
299
18
ID

FIG. 1S2



Application:
- Botton scanner

FIG 1T

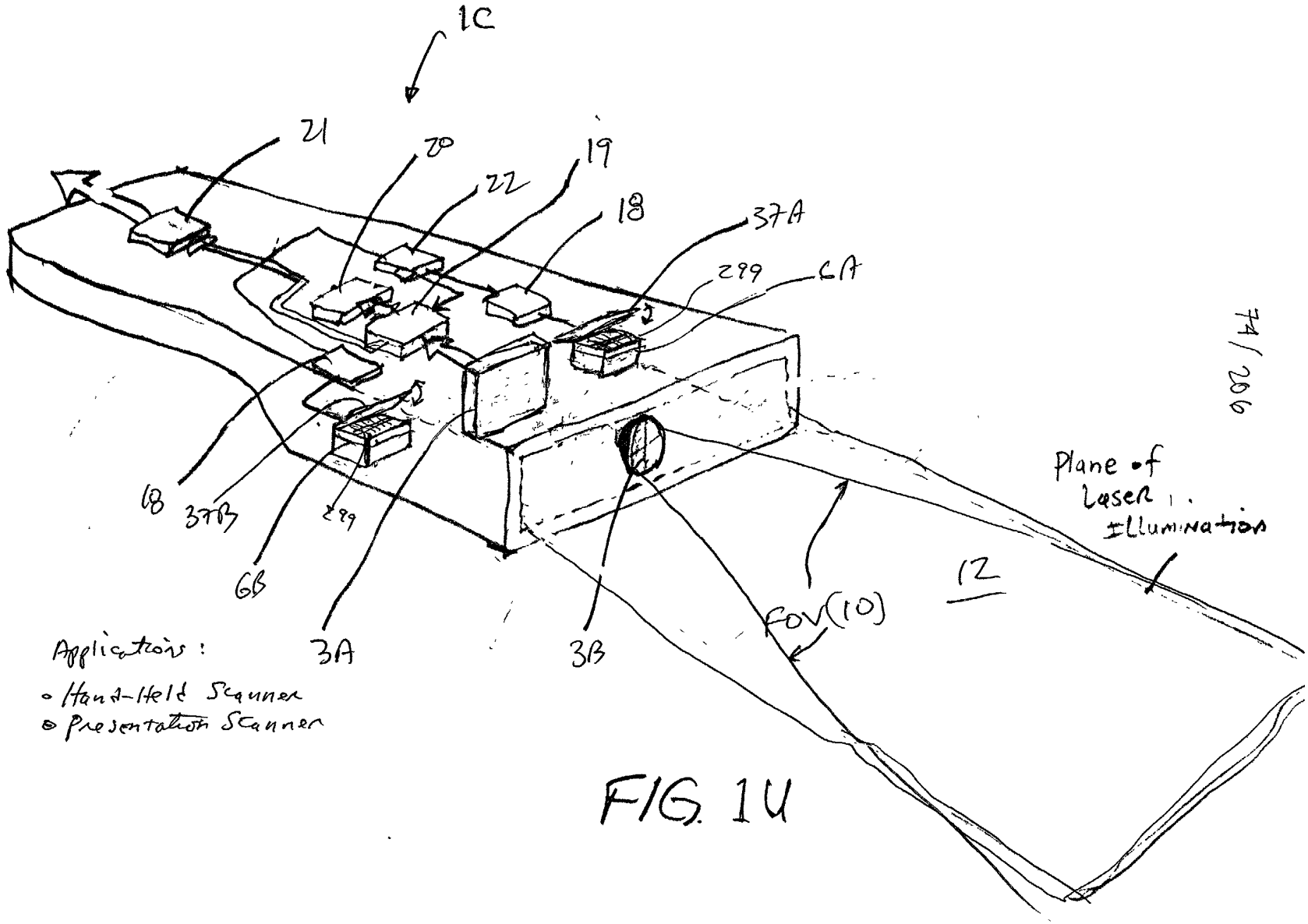

1C
21
20
22
19
18
37A
289
CA
16
37B
289
GB
3A
3B
Plane of Laser Illumination
12
FOV(10)
Applications:
- Hand-Held Scanner
- Presentation Scanner

FIG. 1U

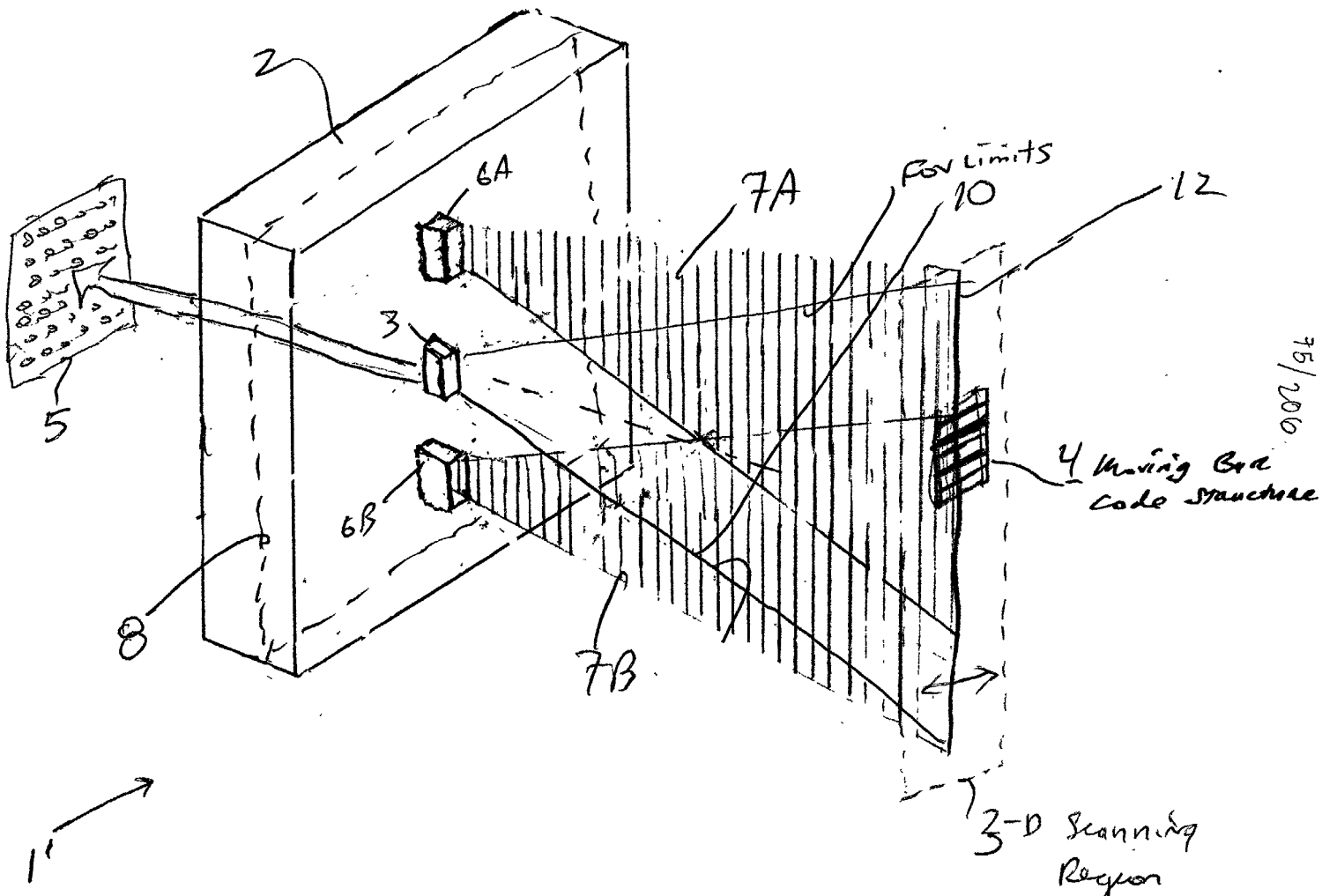


FIG. IVI

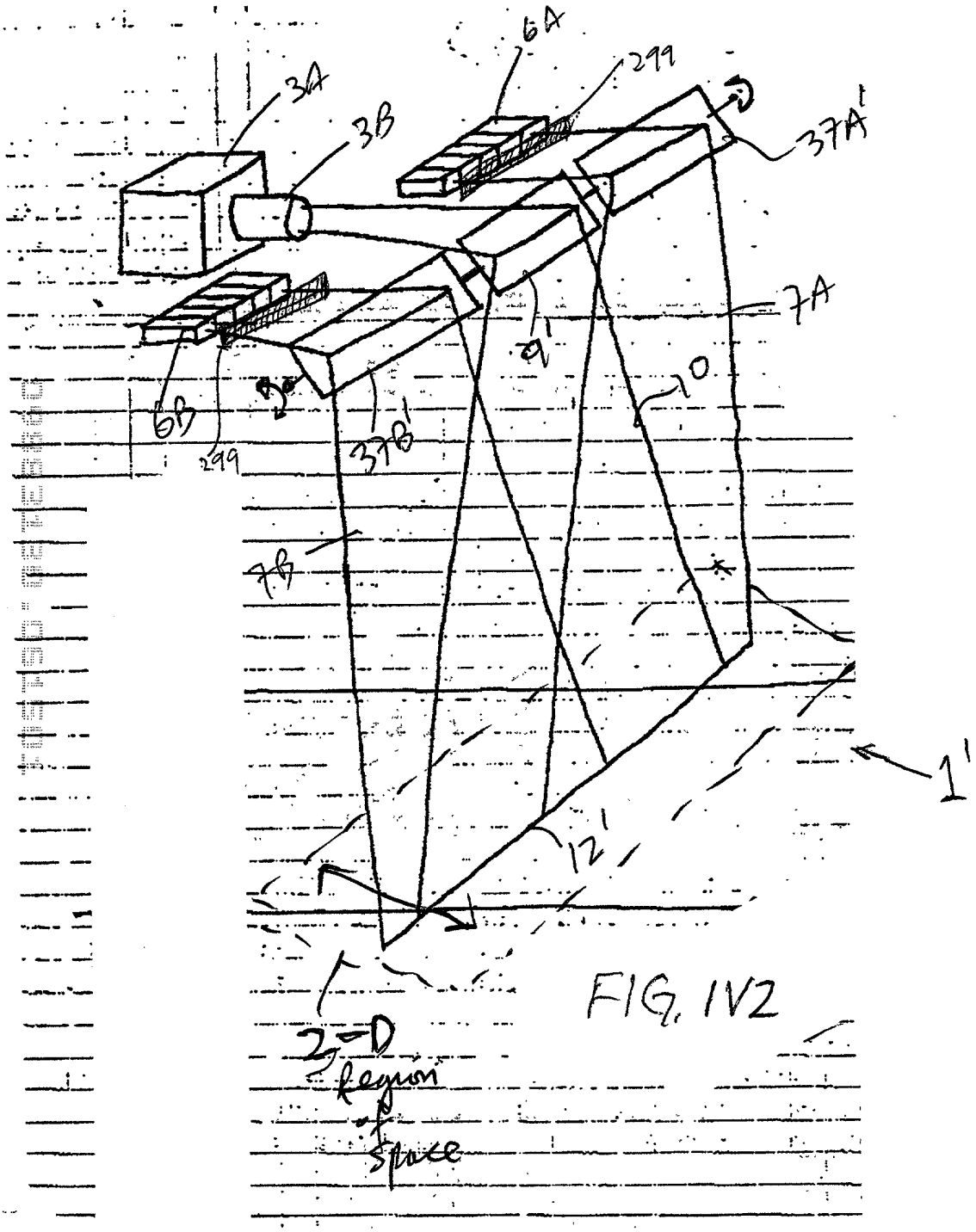


FIG. 1V2

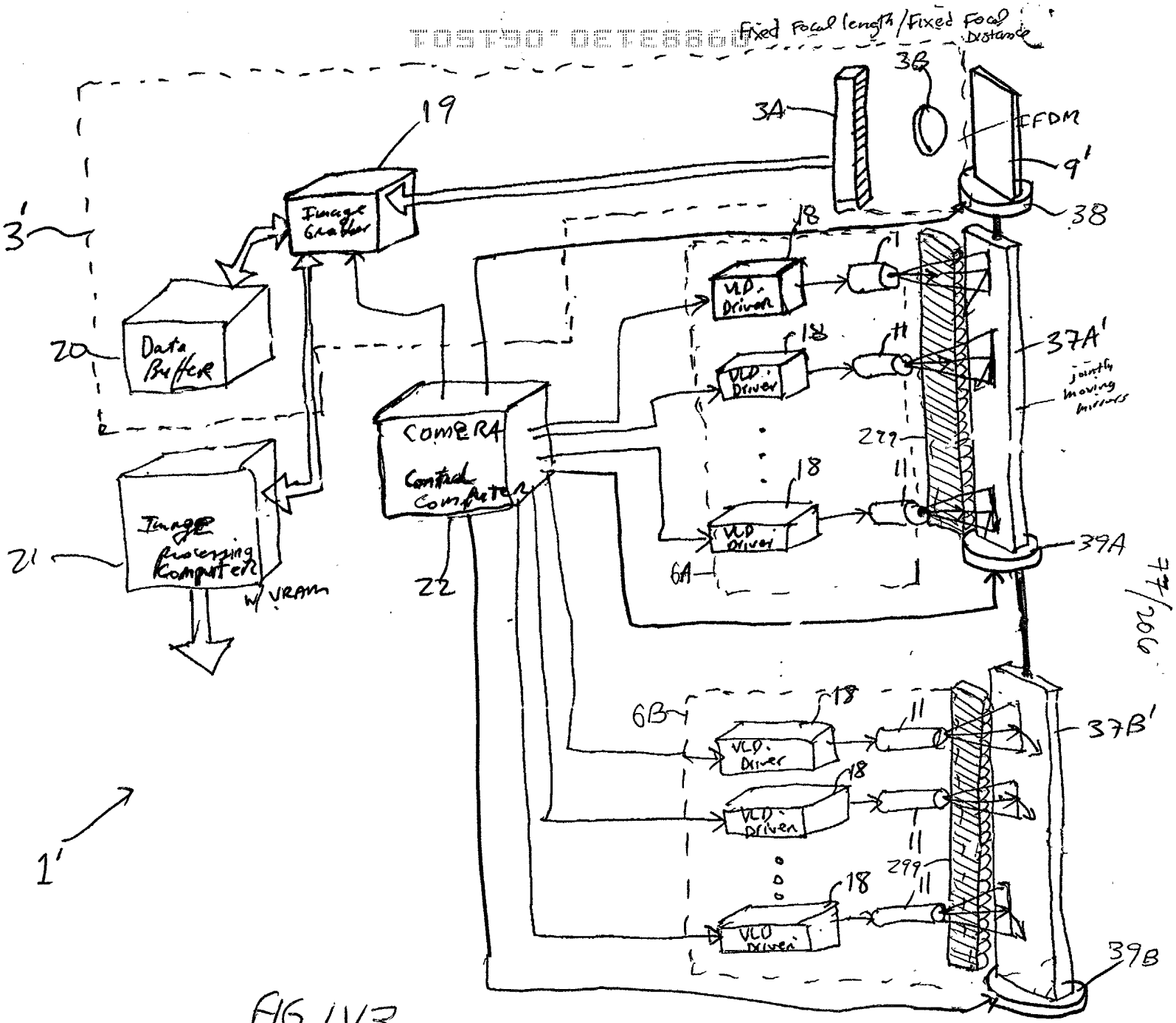
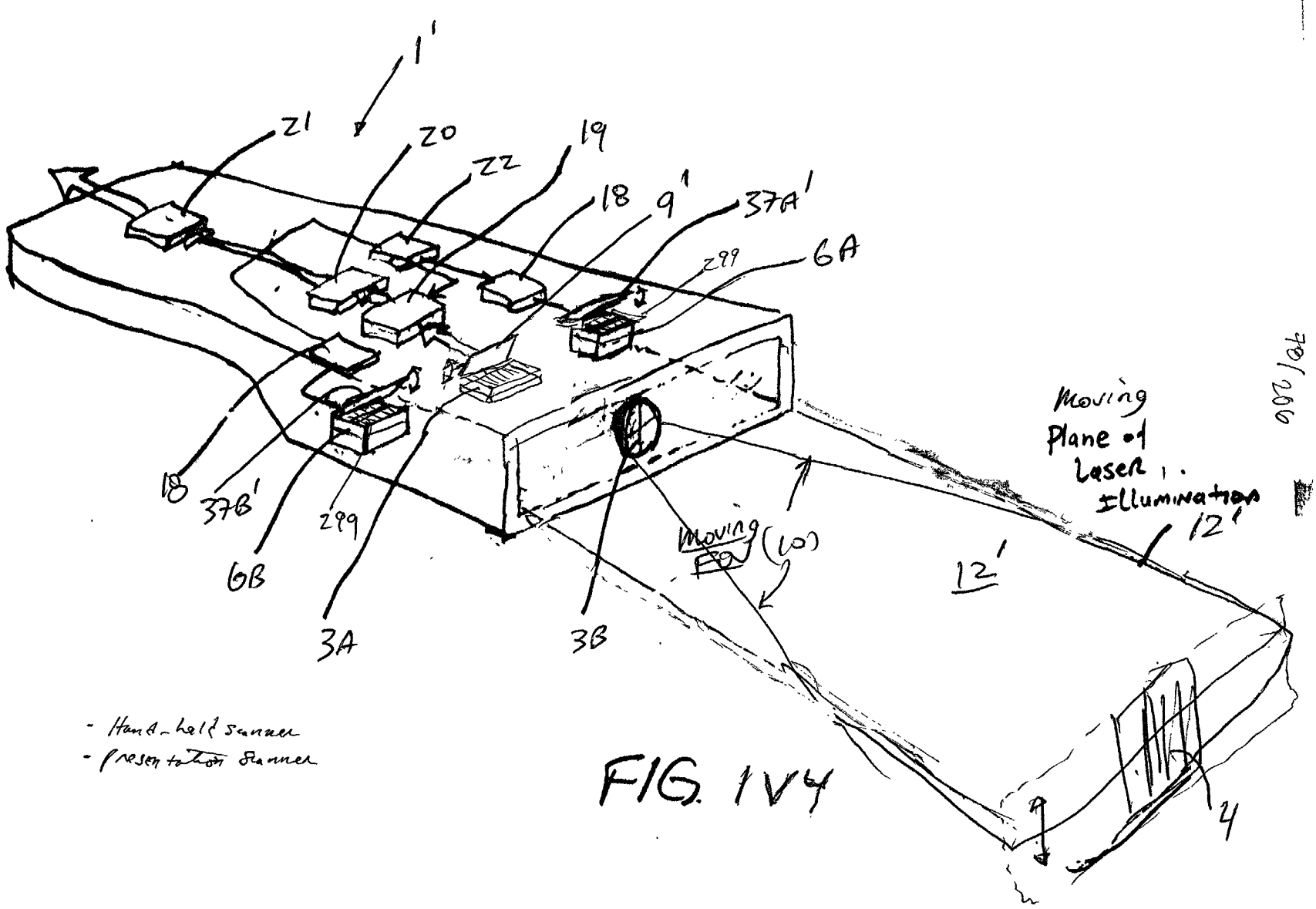
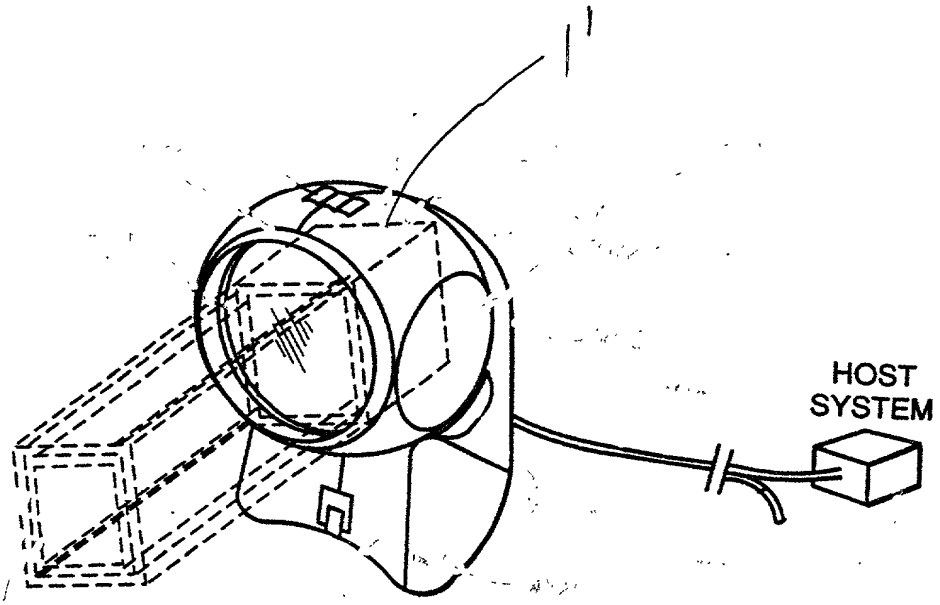


FIG. 1V3



- Hand-held scanner
- Presentation Scanner

FIG. 1V4



(Presentation-type scanner)

FIG. 1V5

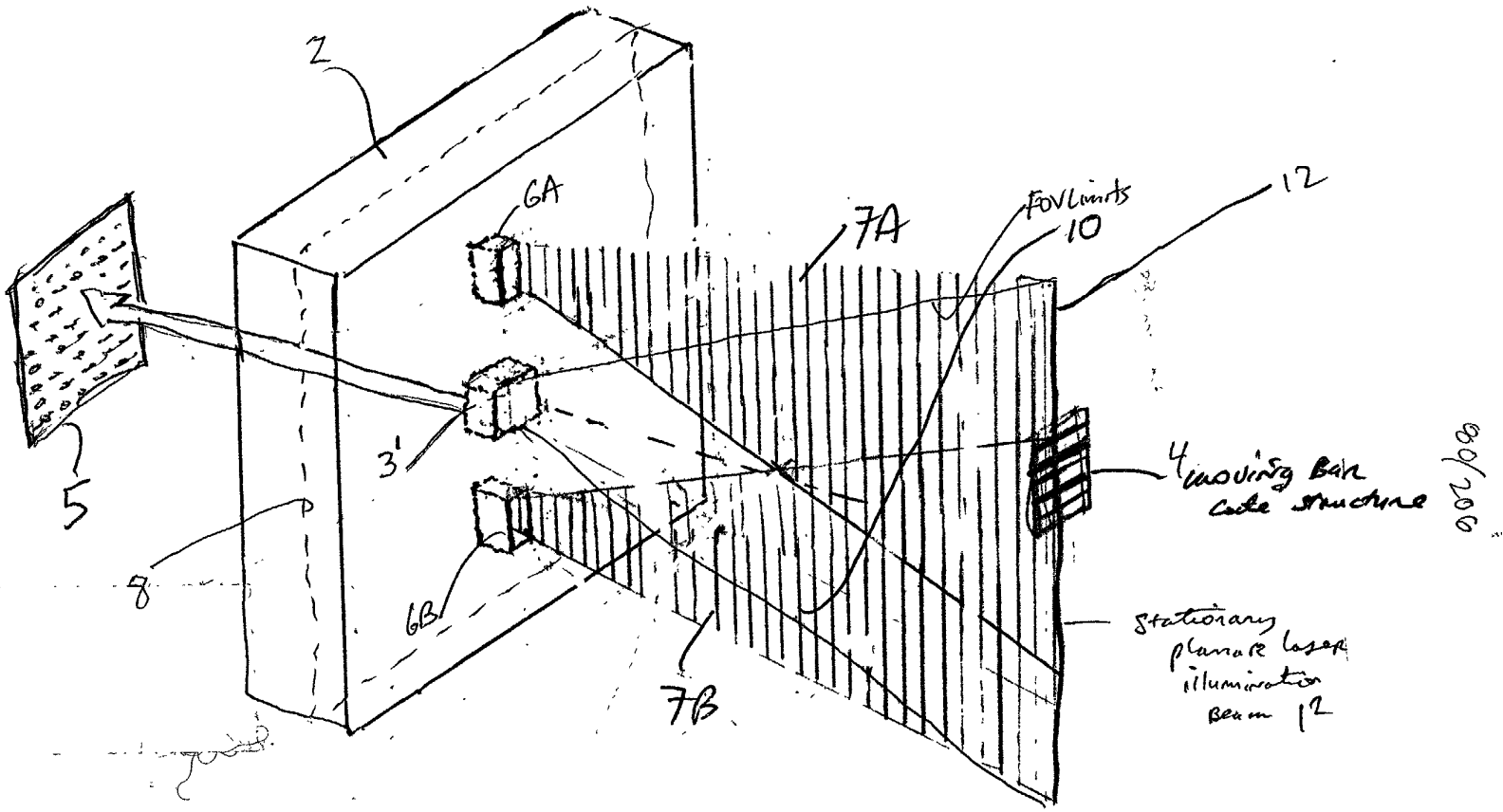


FIG. 2A

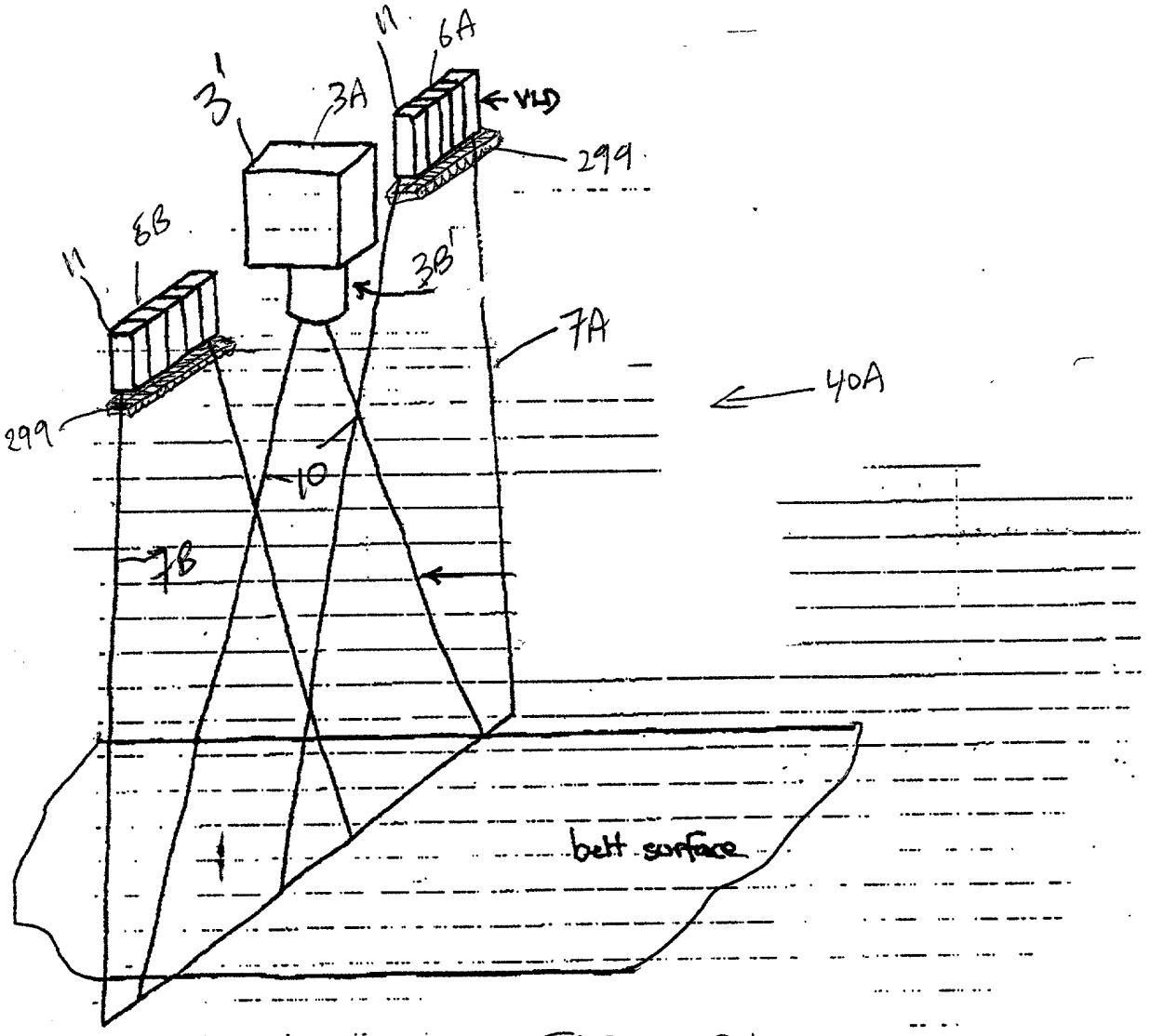


FIG. 2B1

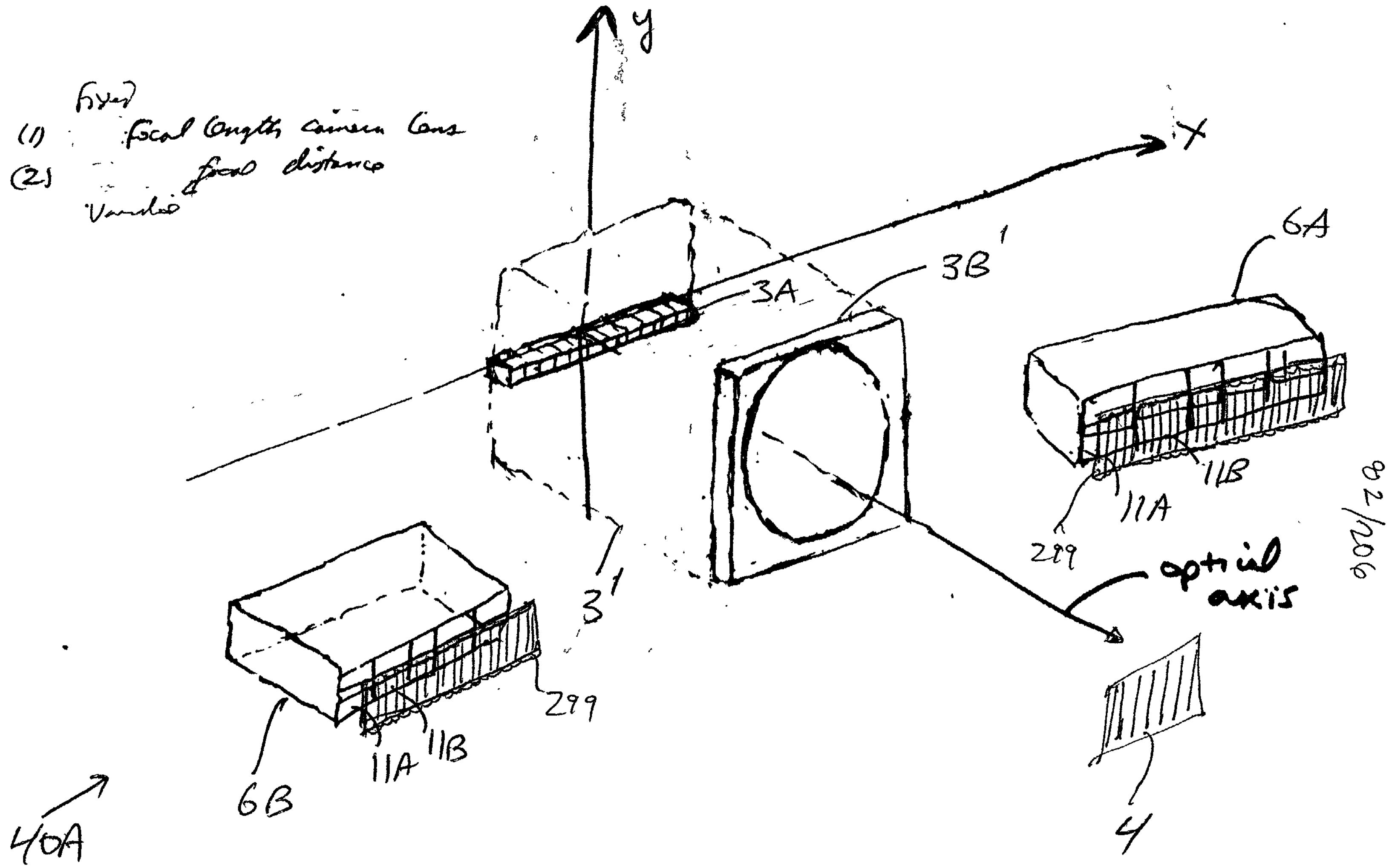


FIG. 2B2

82/206

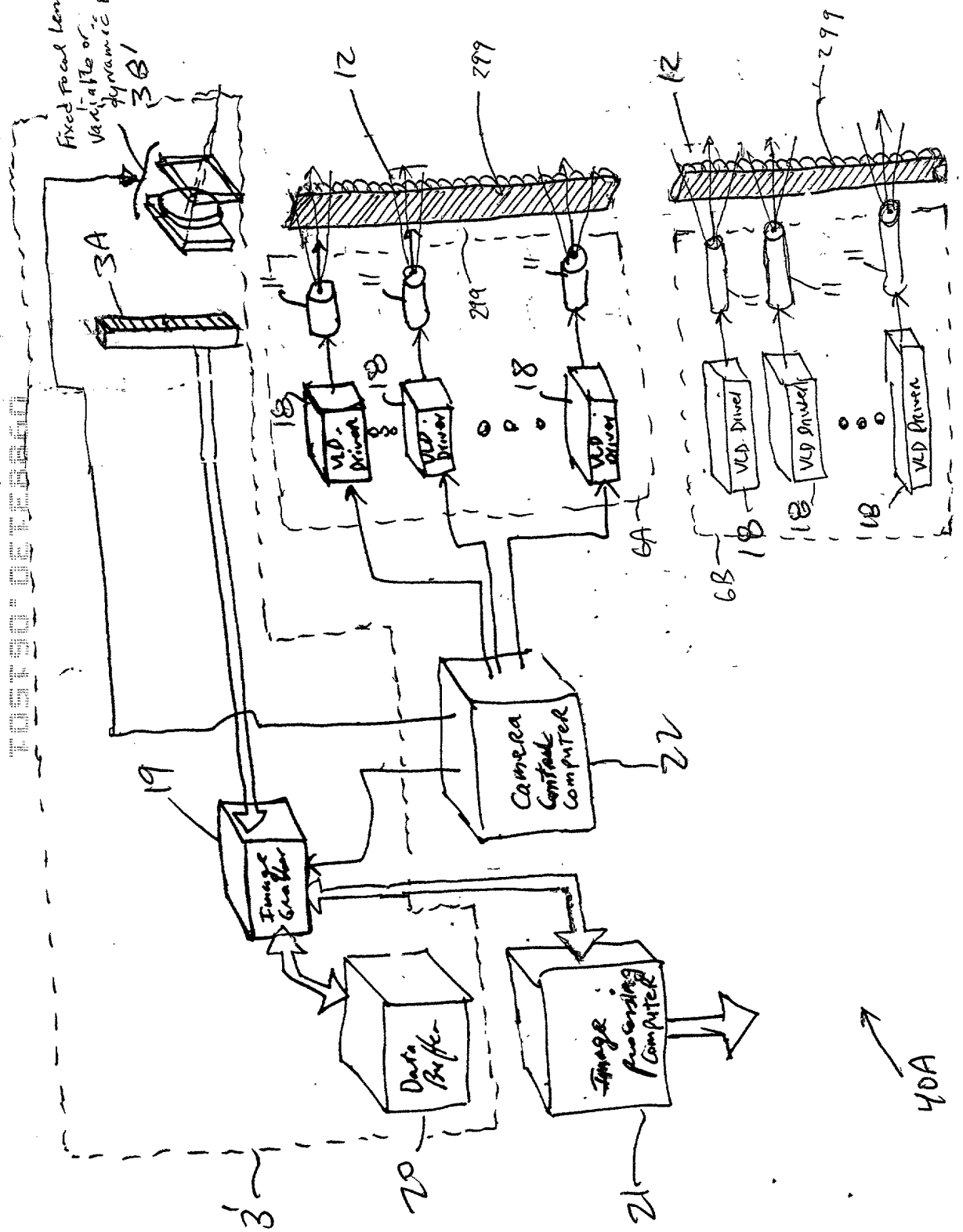

Fixed Focal Length or Variable or Dynamic Focus
38
3A
12
299
18
VLD Driver
Camera Control Computer
22
Image Grabber
19
Data Buffer
20
Image Processing Computer
21
3
40A
6A
6B

FIG 2C1

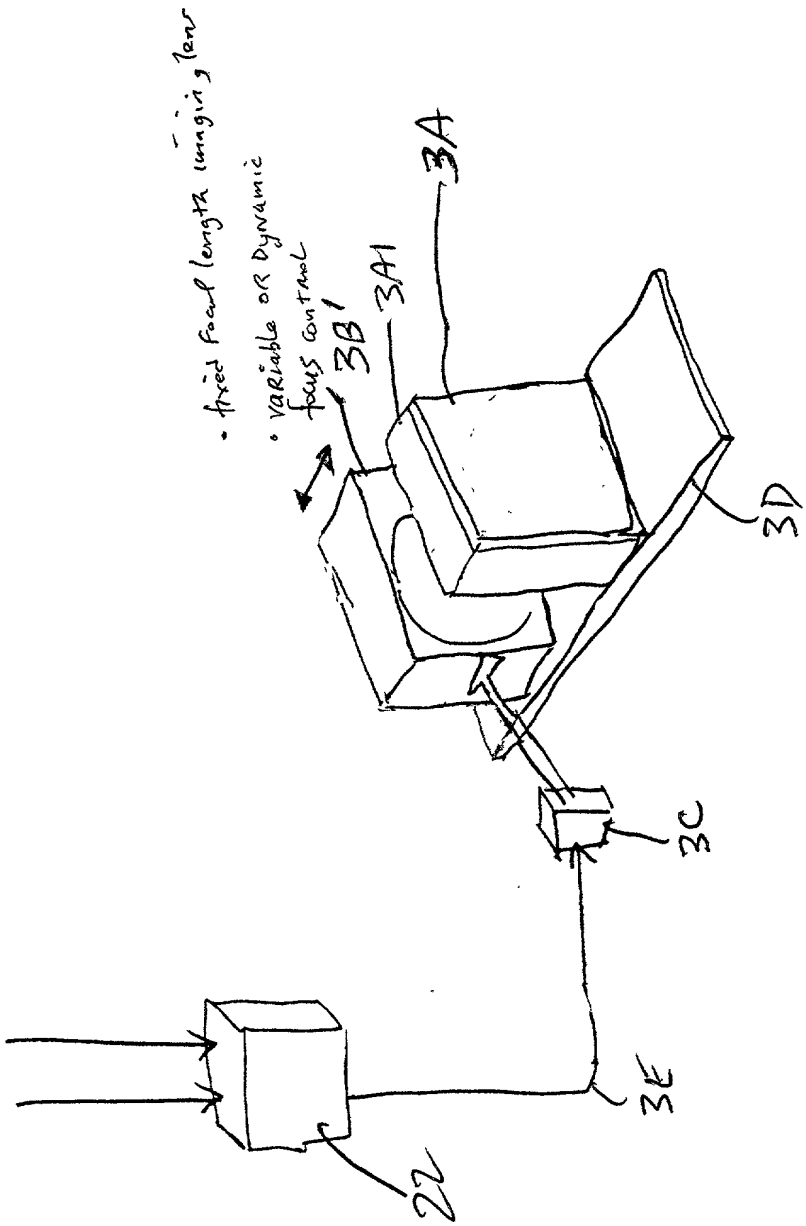

• fixed focal length imaging lens
• variable or dynamic focus control
3B'
3A1
3A
3D
3C
3E
22
3'

FIG. 2C2

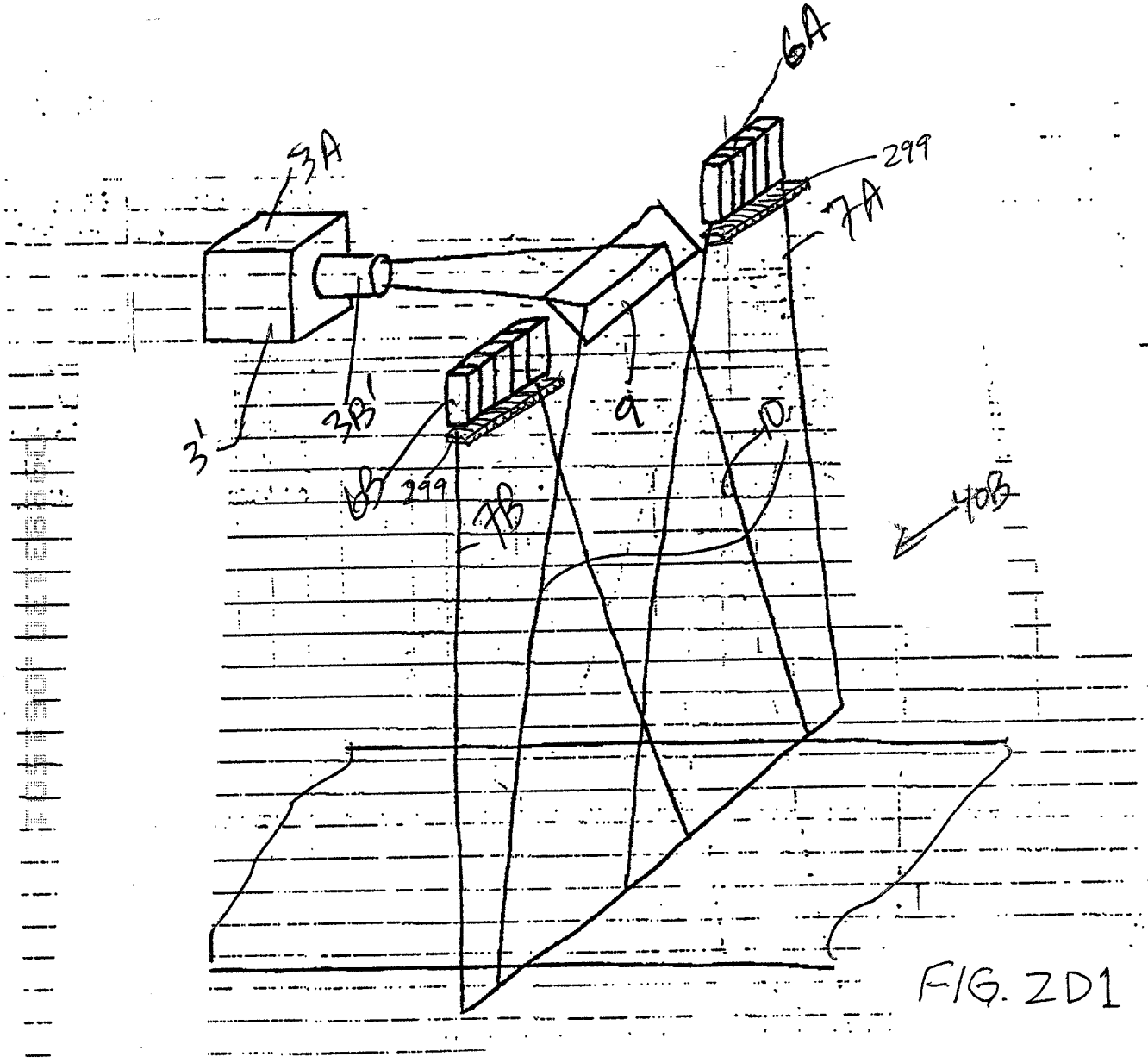


FIG. 2D1

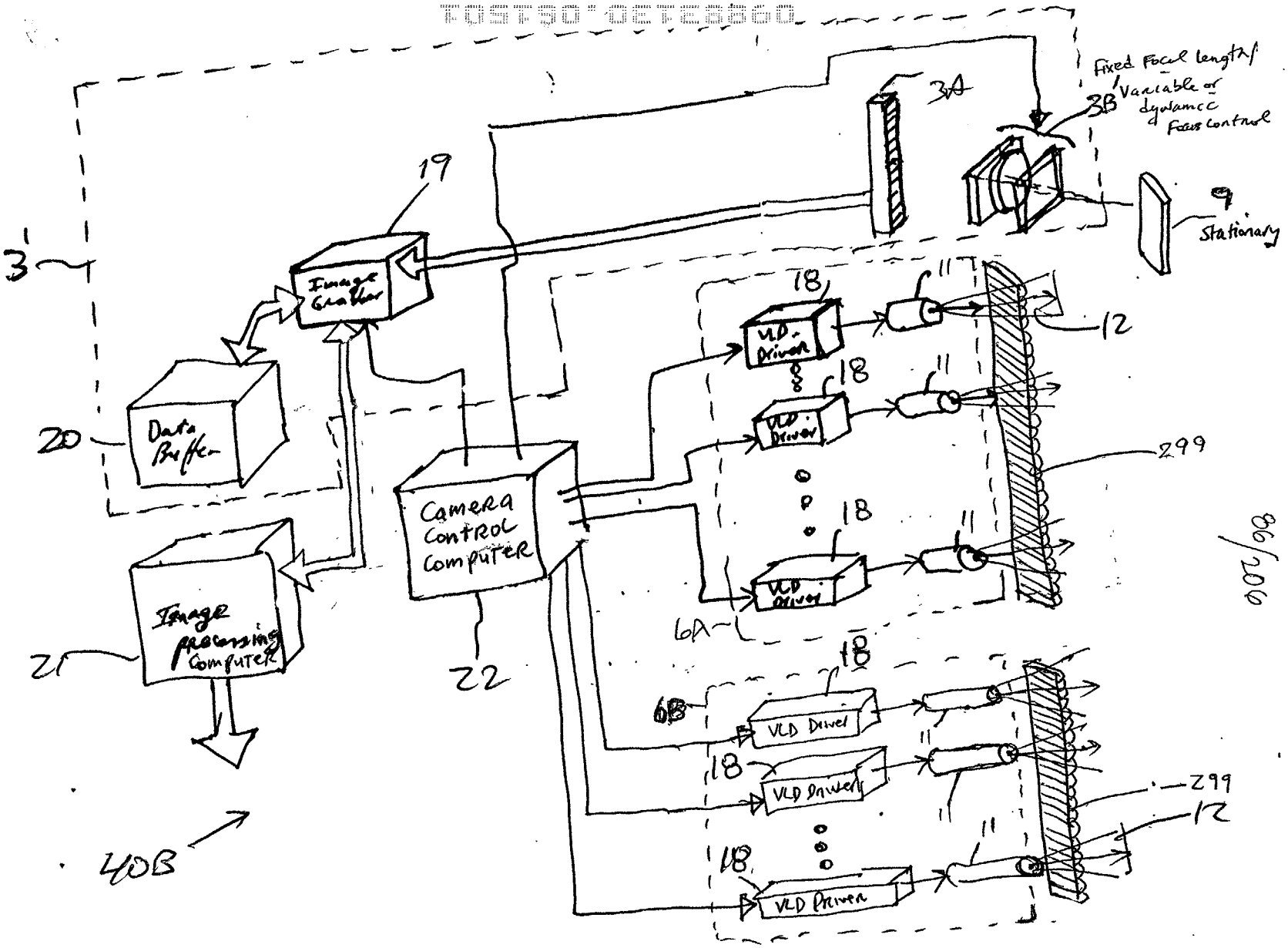


FIG. 2D2

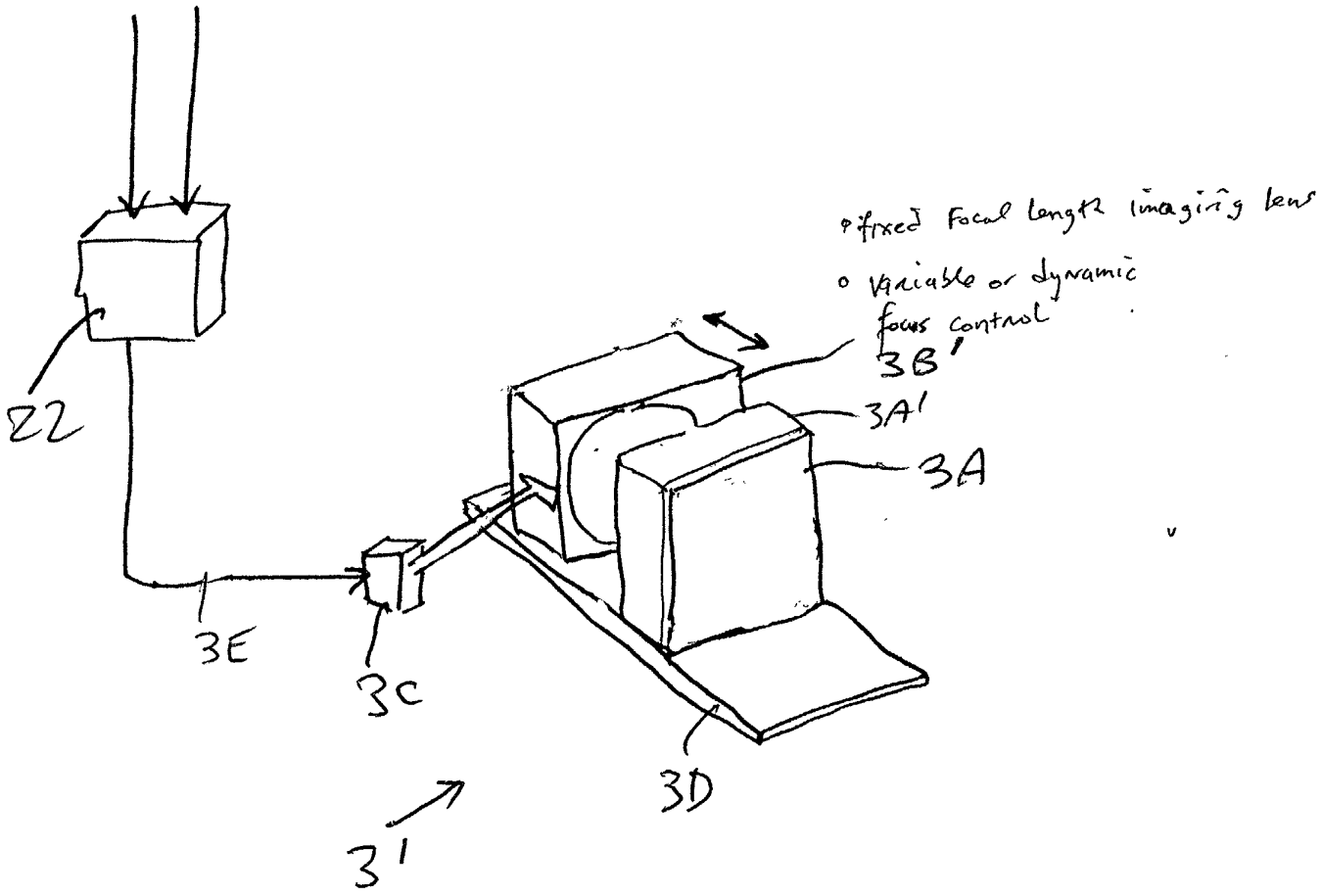

• fixed Focal length imaging lens
o Variable or dynamic focus control
3B'
3A'
3A
22
3E
3C
3D
3'

FIG. 2D3

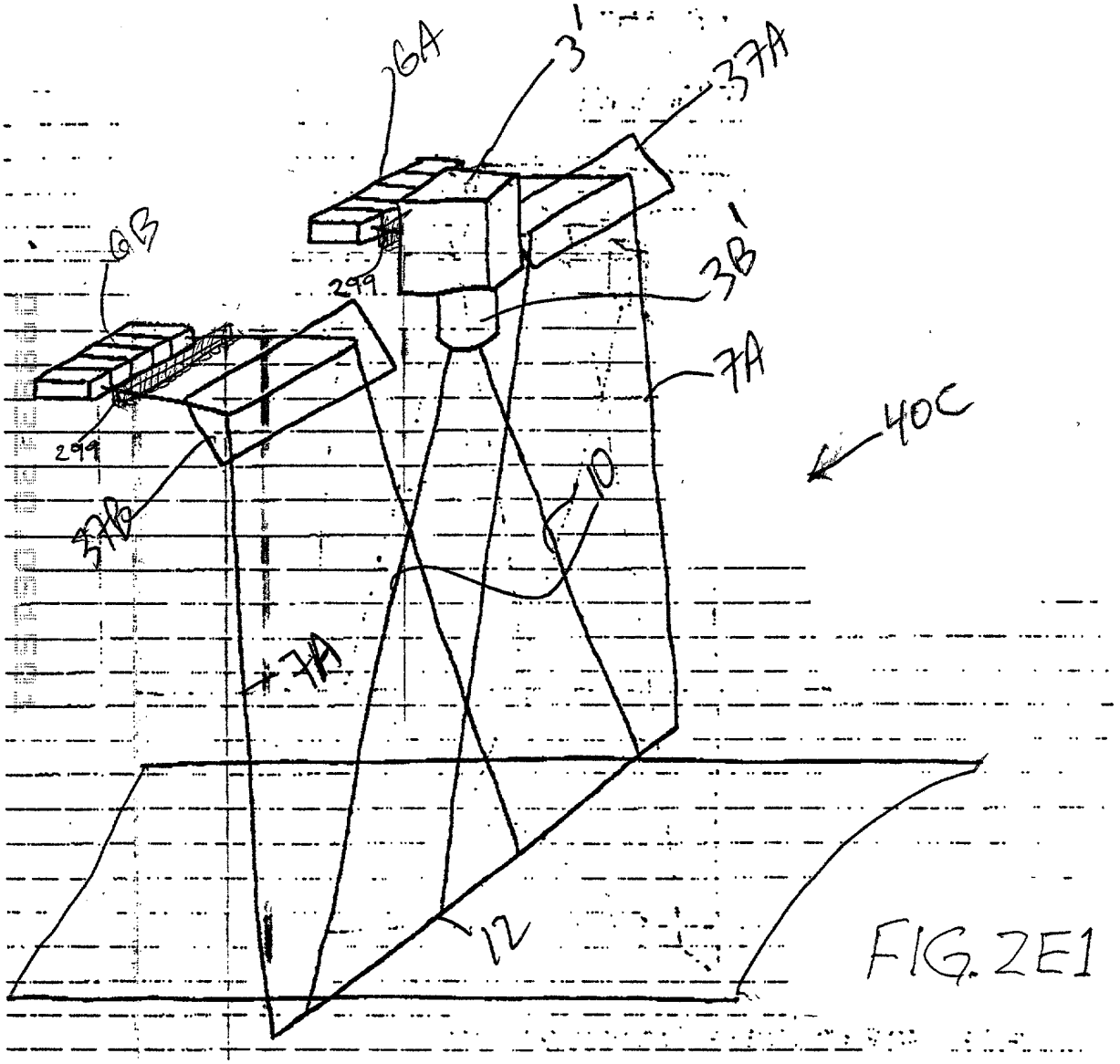


FIG. 2E1

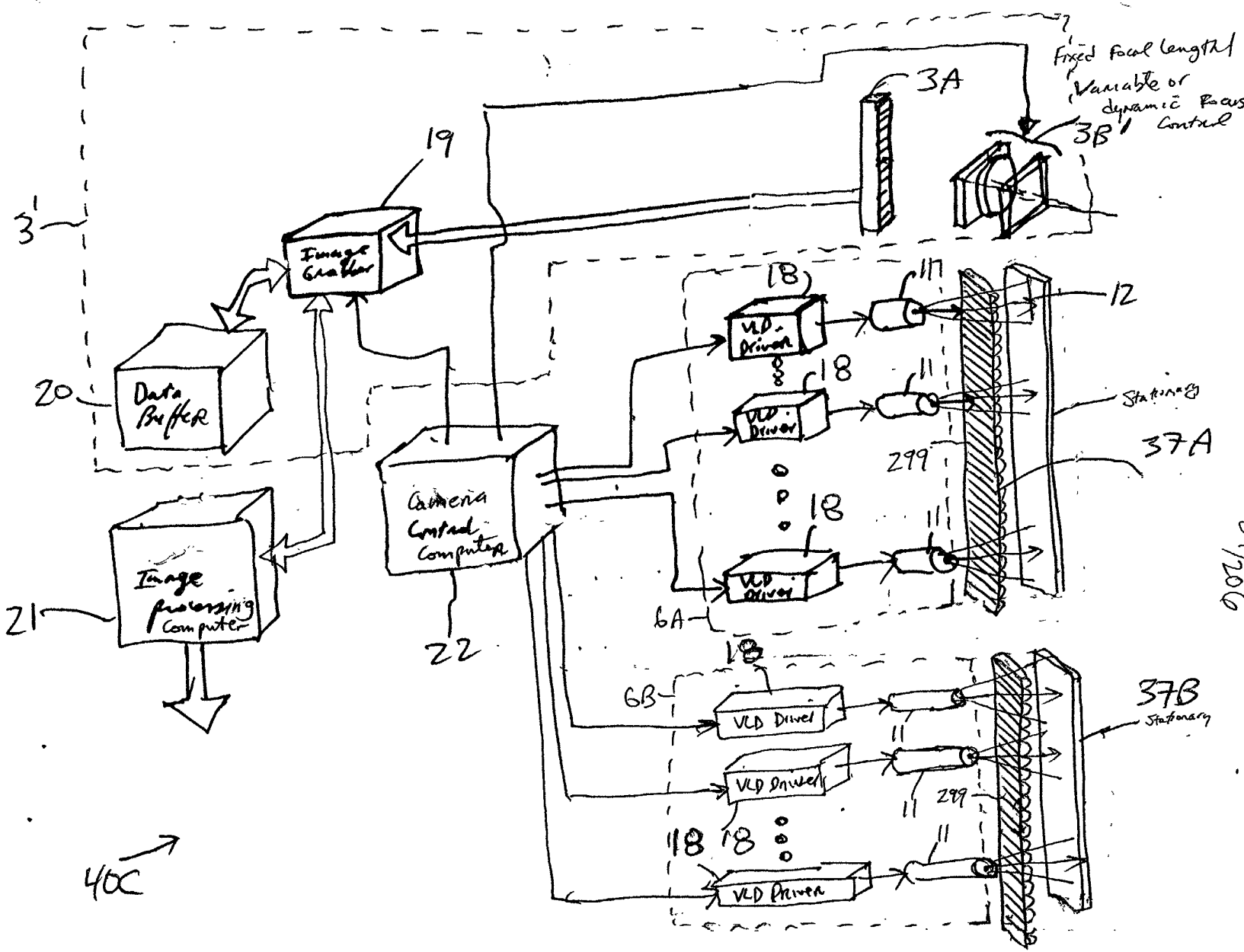


FIG. 2E2

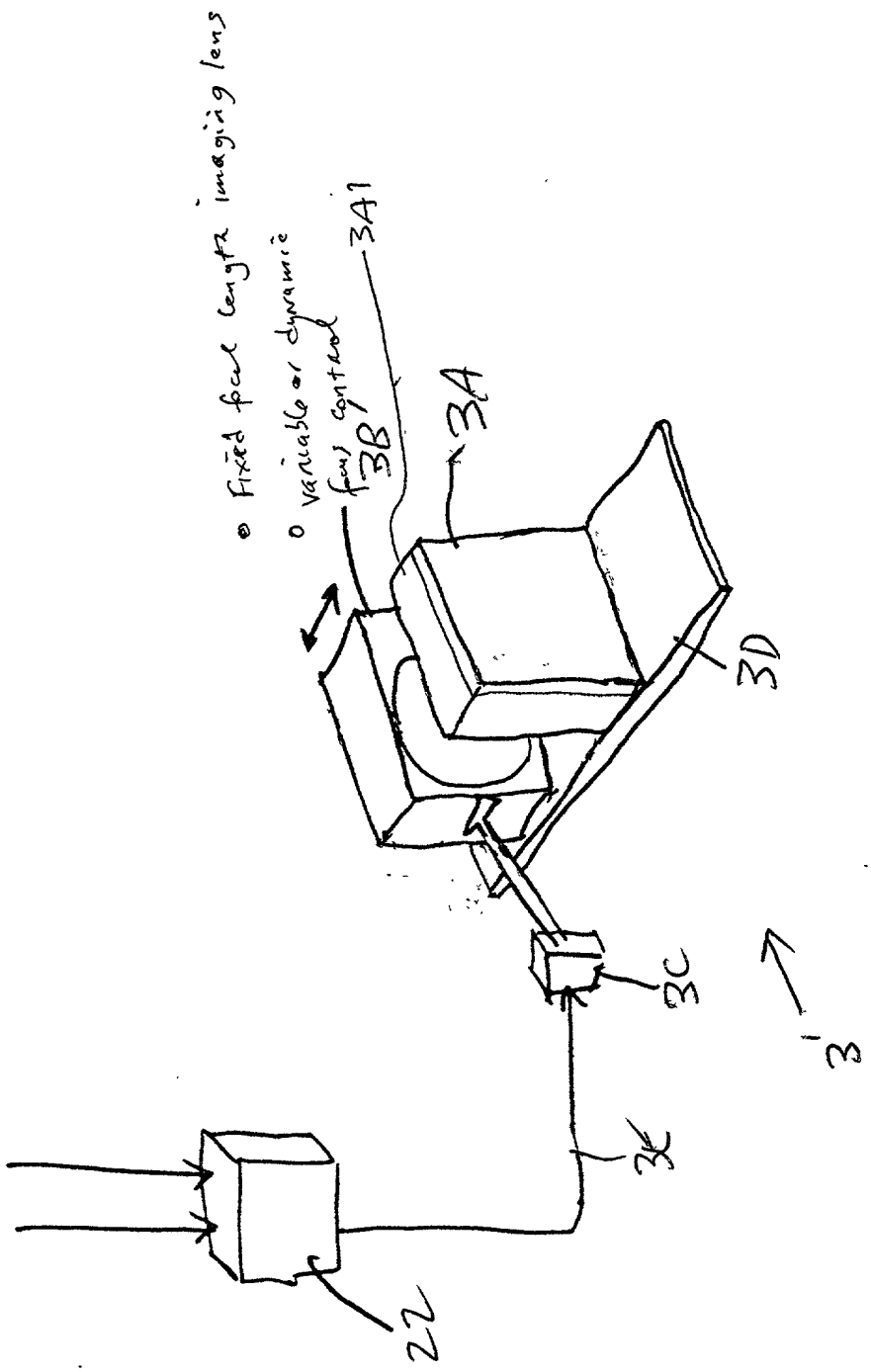

• Fixed focal length imaging lens
○ variable or dynamic focus control
3A1
3B
34
3D
3C
3
3E
22

FIG. 2E3

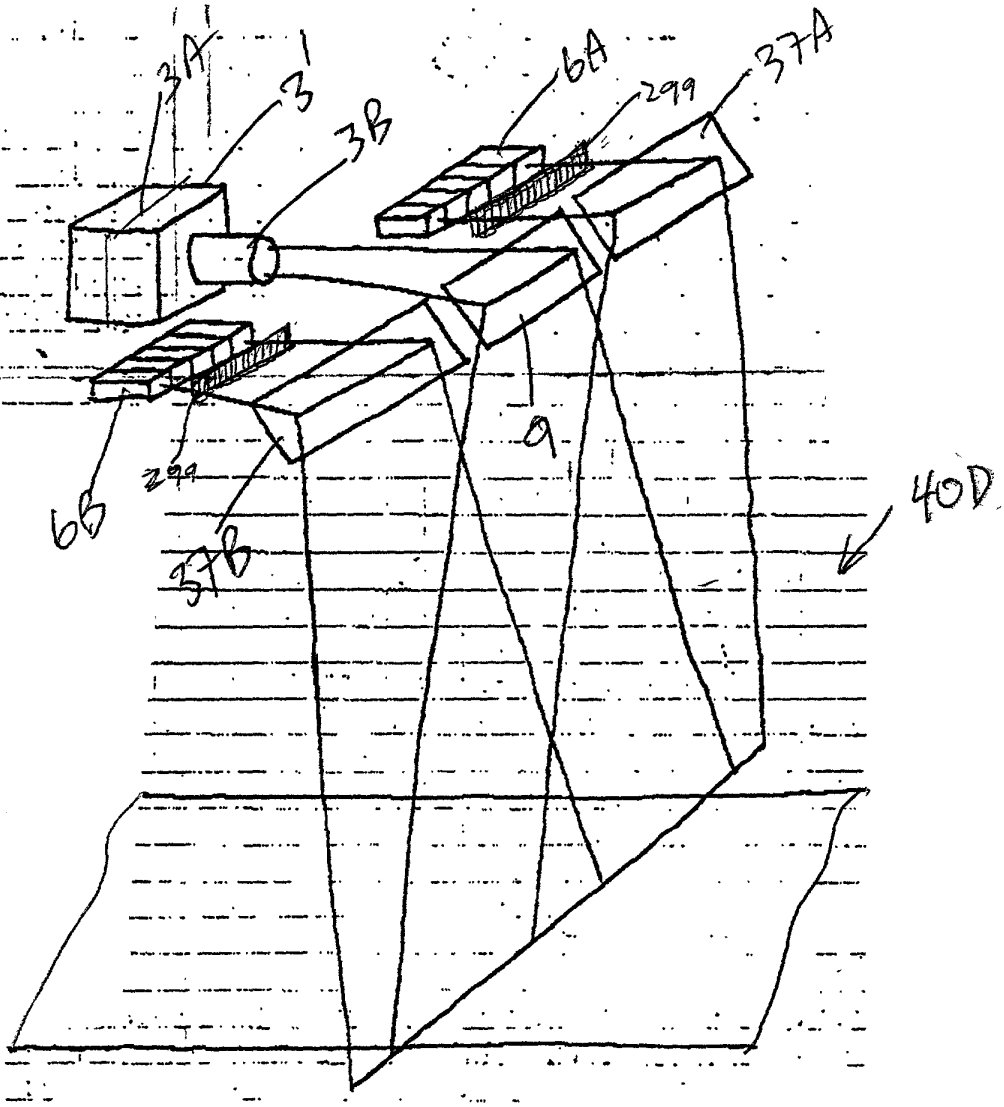


FIG. 2F1

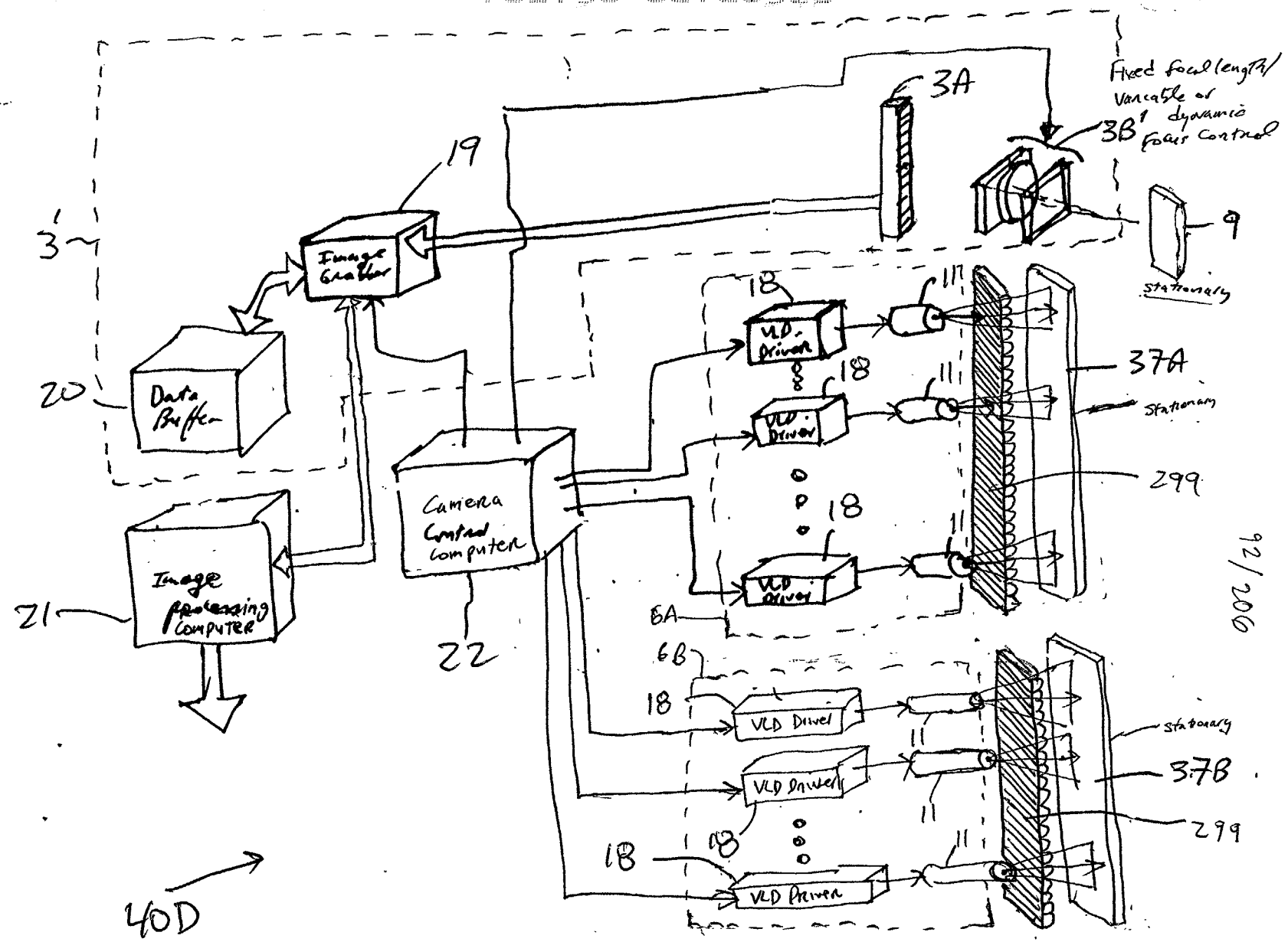


FIG 2F2

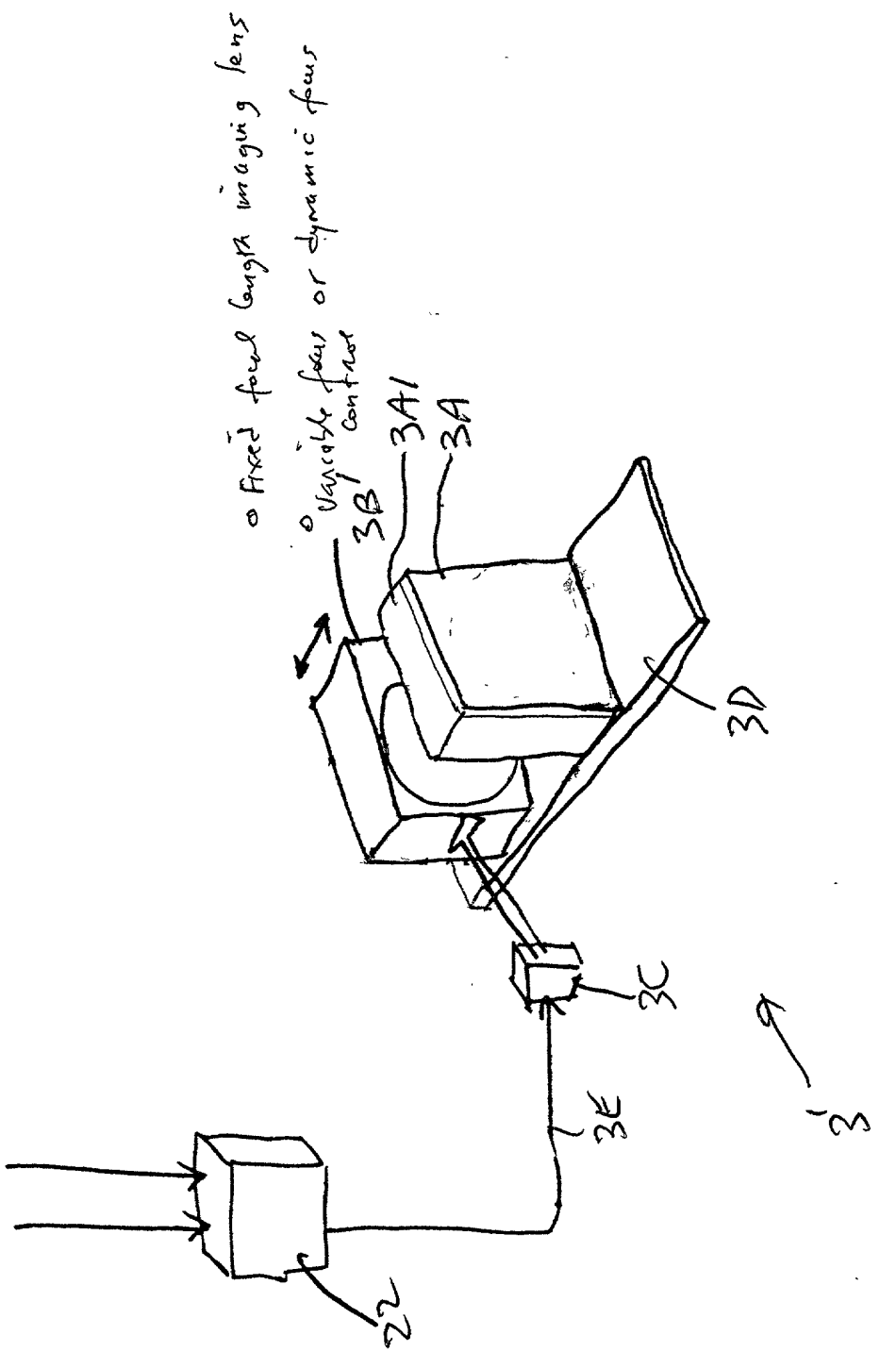

o Fixed focal length imaging lens
o Variable focus or dynamic focus control
3B
3A1
3A
3D
3C
3E
3
22

FIG. 2F3

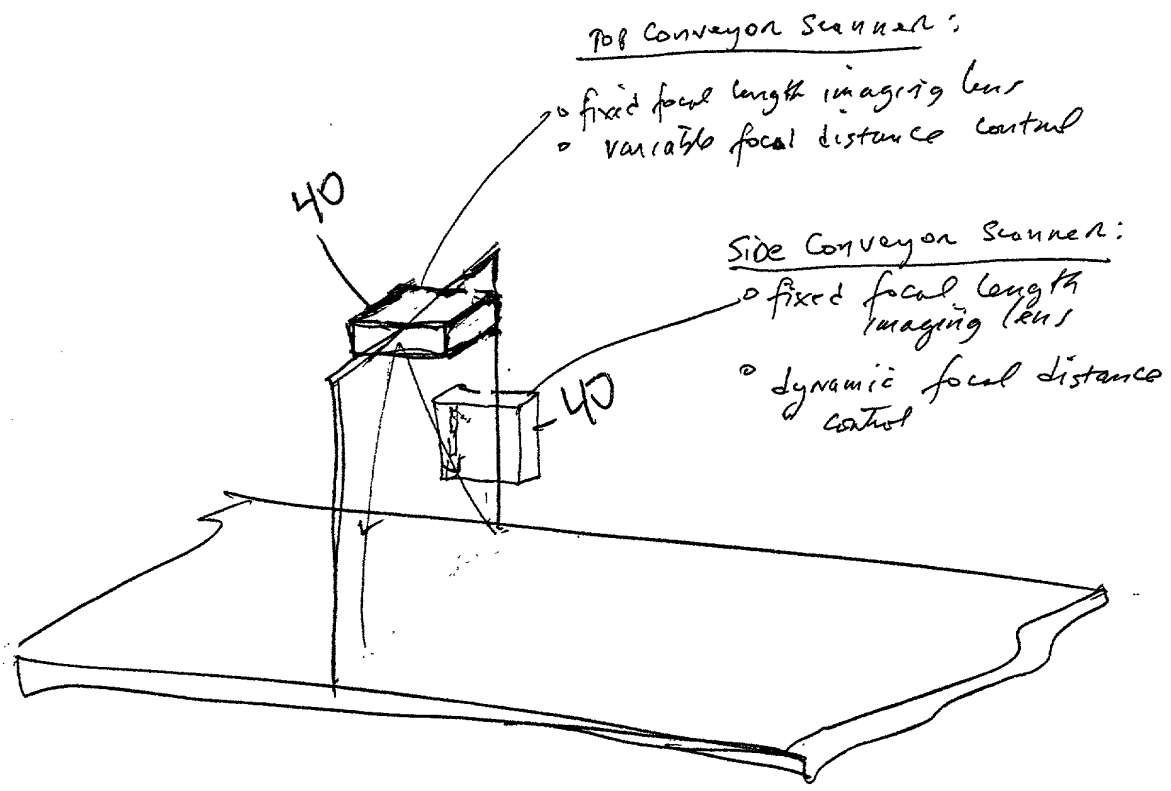

Top Conveyor Scanner:
o fixed focal length imaging lens
o variable focal distance control
40
Side Conveyor Scanner:
o fixed focal length imaging lens
o dynamic focal distance control
40

FIG. 2G

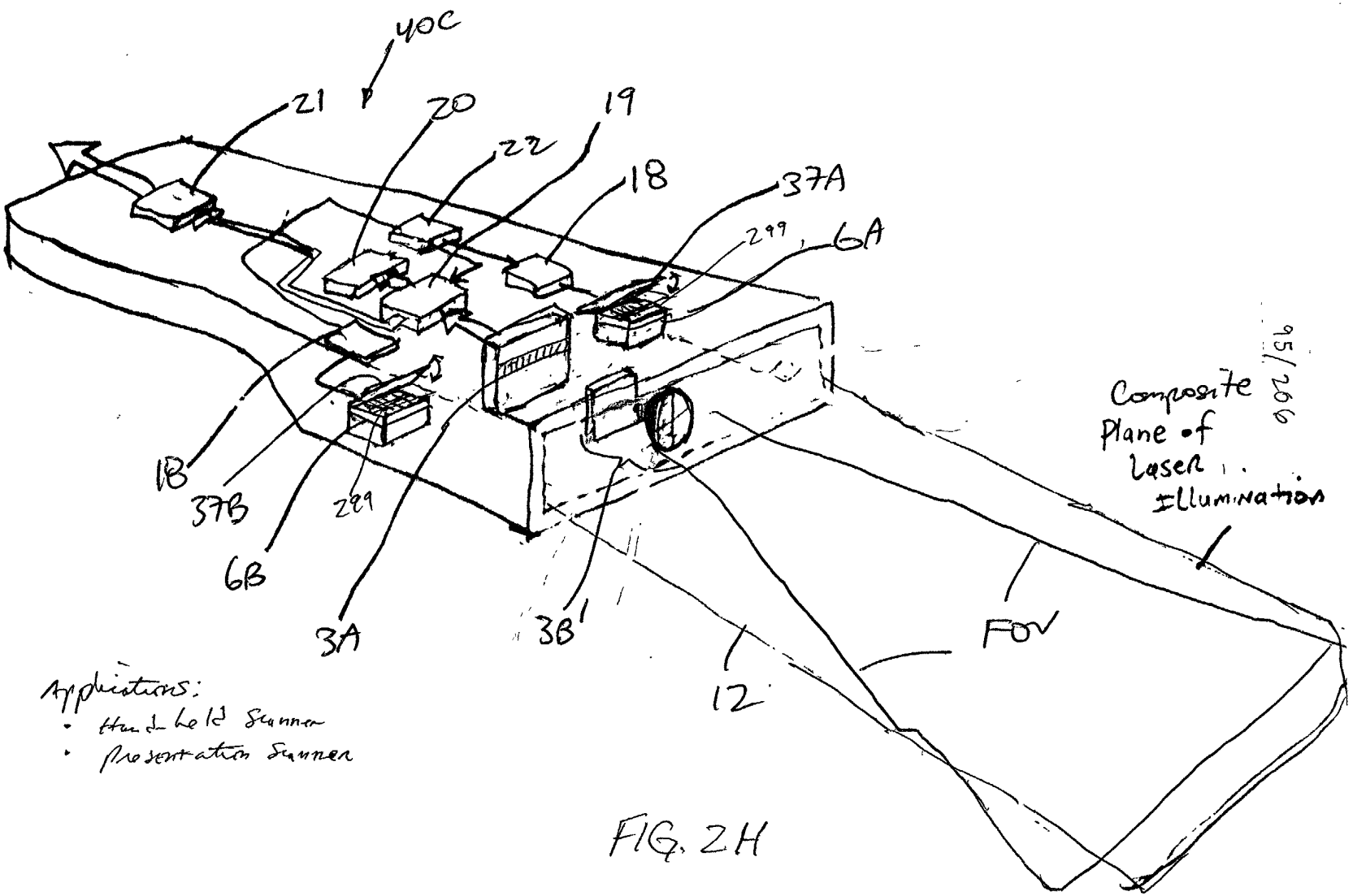


FIG. 2H

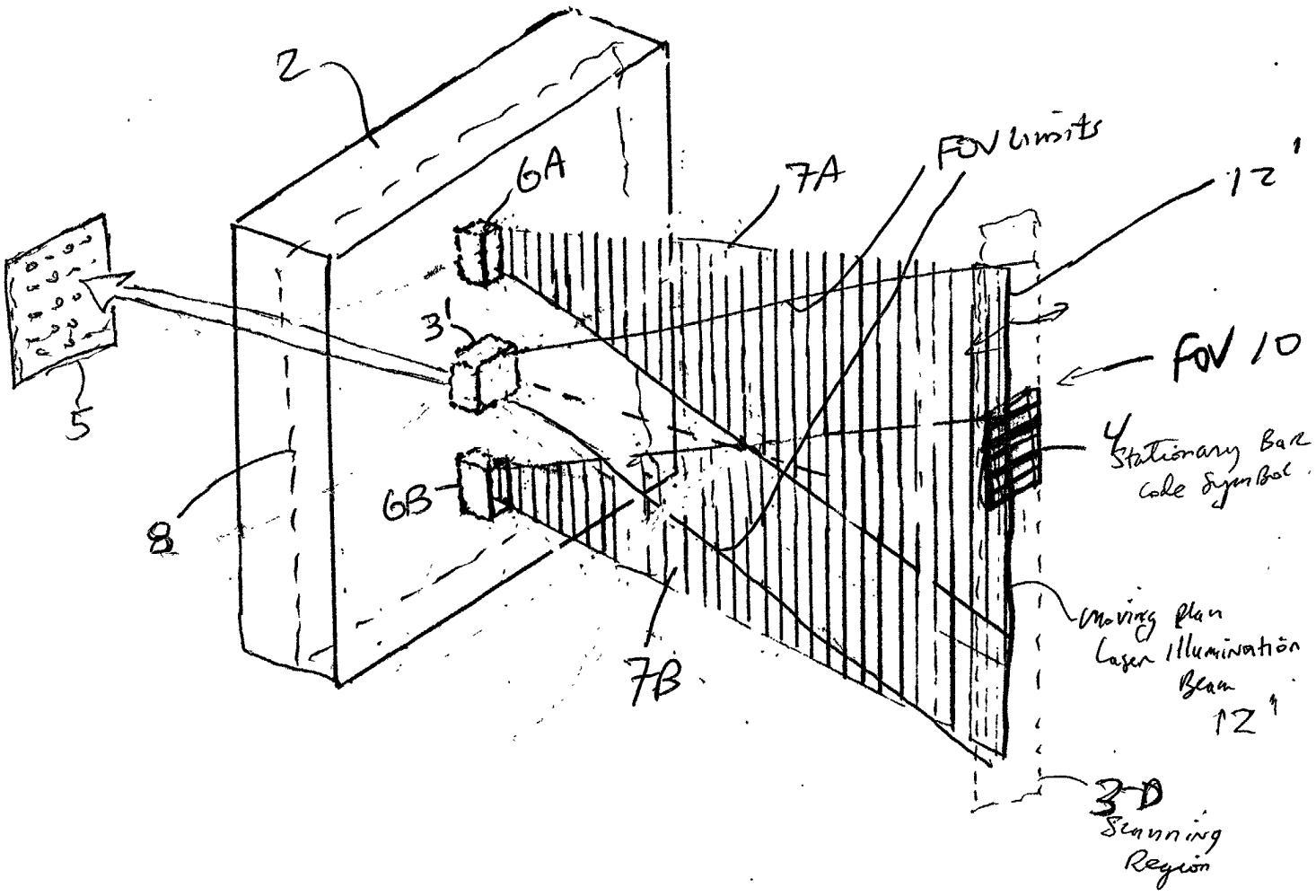

2
6A
7A
FOV limits
12'
3'
FOV 10
5
4 Stationary Bar Code Symbol
8
6B
Moving Plan Laser Illumination Beam 12'
7B
3D Scanning Region
40'

FIG. 2I1

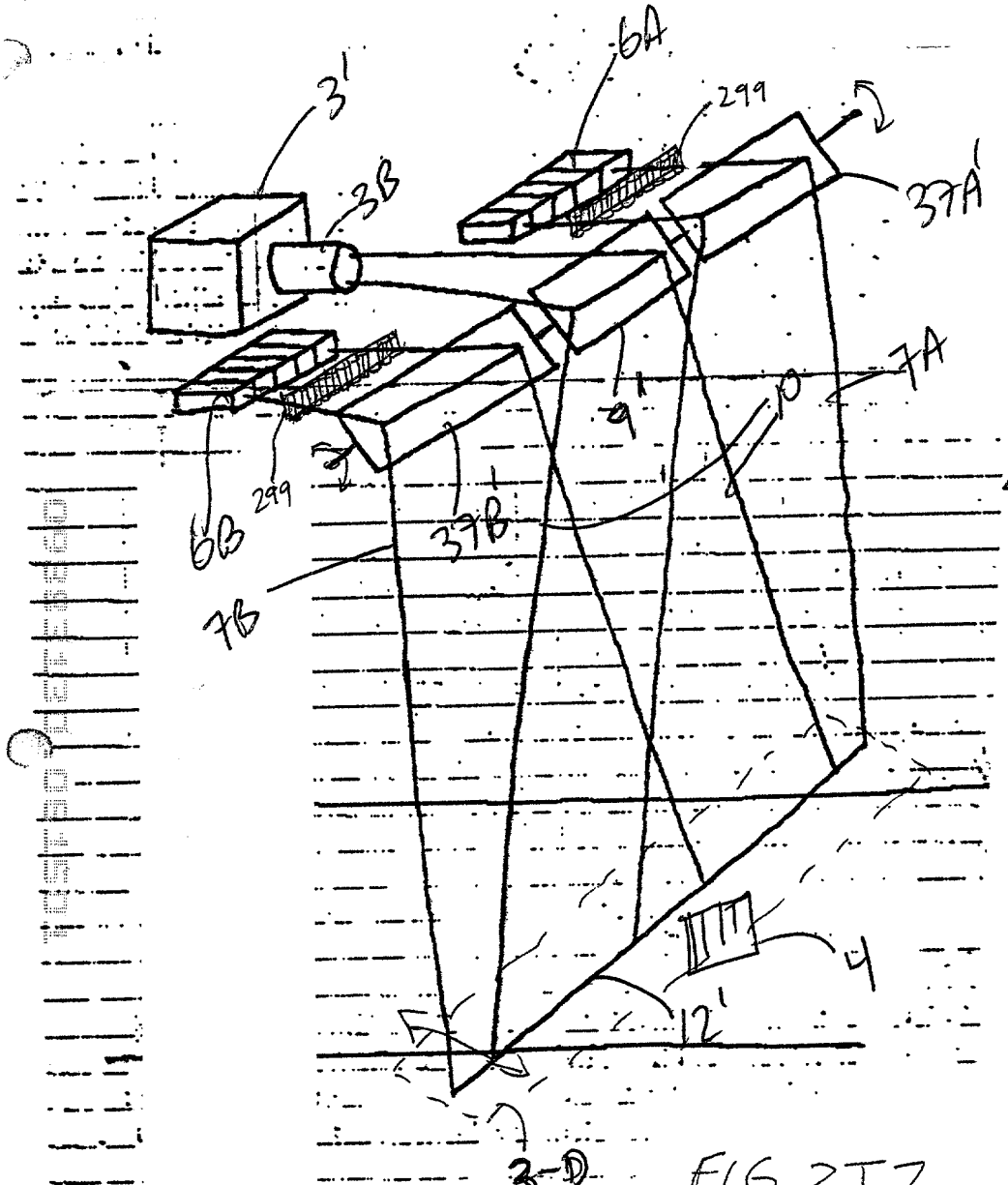


FIG 2I2

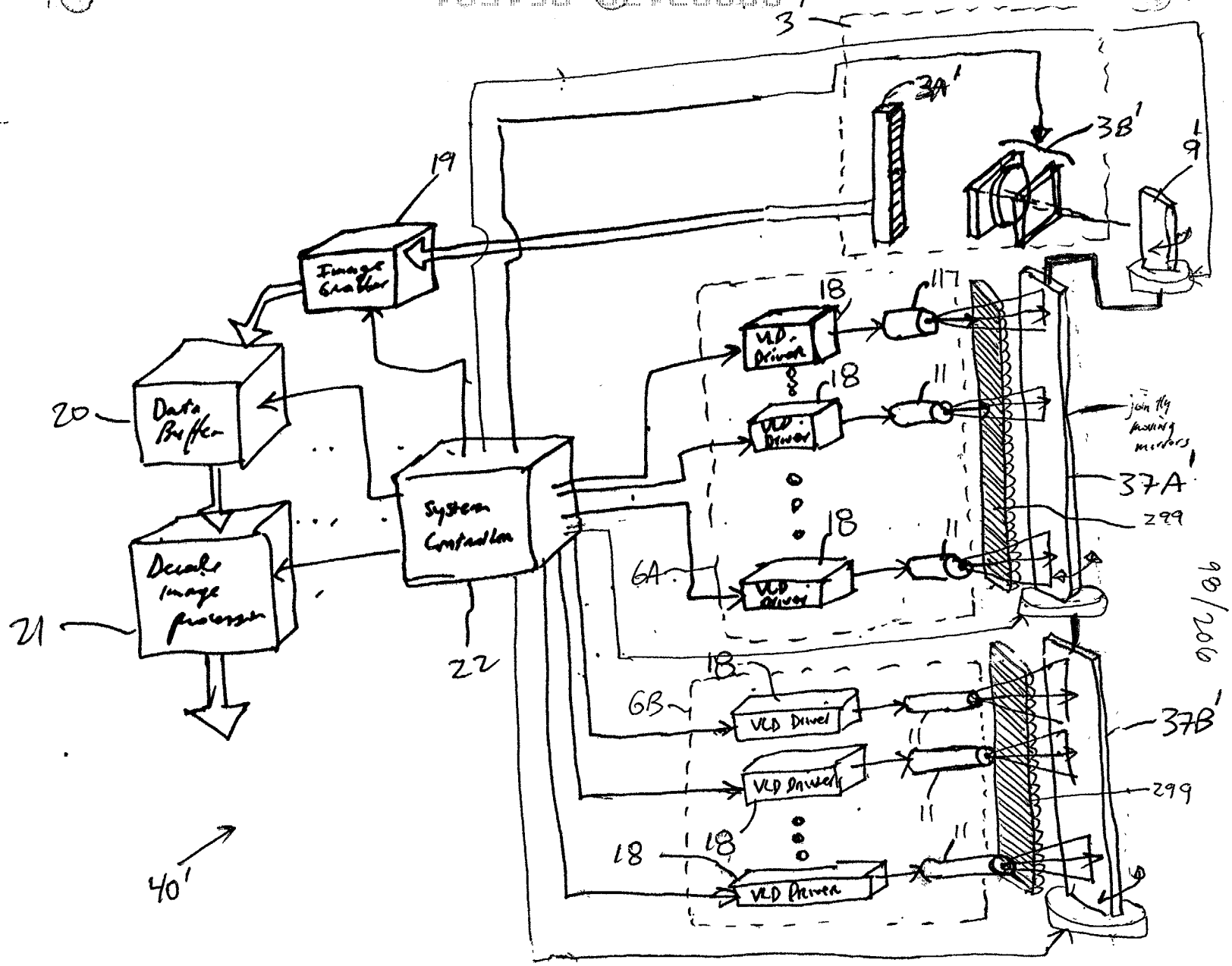

3'
3A'
3B'
19
Image Creation
20
Data Buffer
21
Decode Image Processor
22
System Controller
18
VLD Driver
VLD Driver
VLD Driver
6A
37A'
299
6B
VLD Driver
VLD Driver
VLD Driver
37B'
299
18
40'

FIG. 2I3

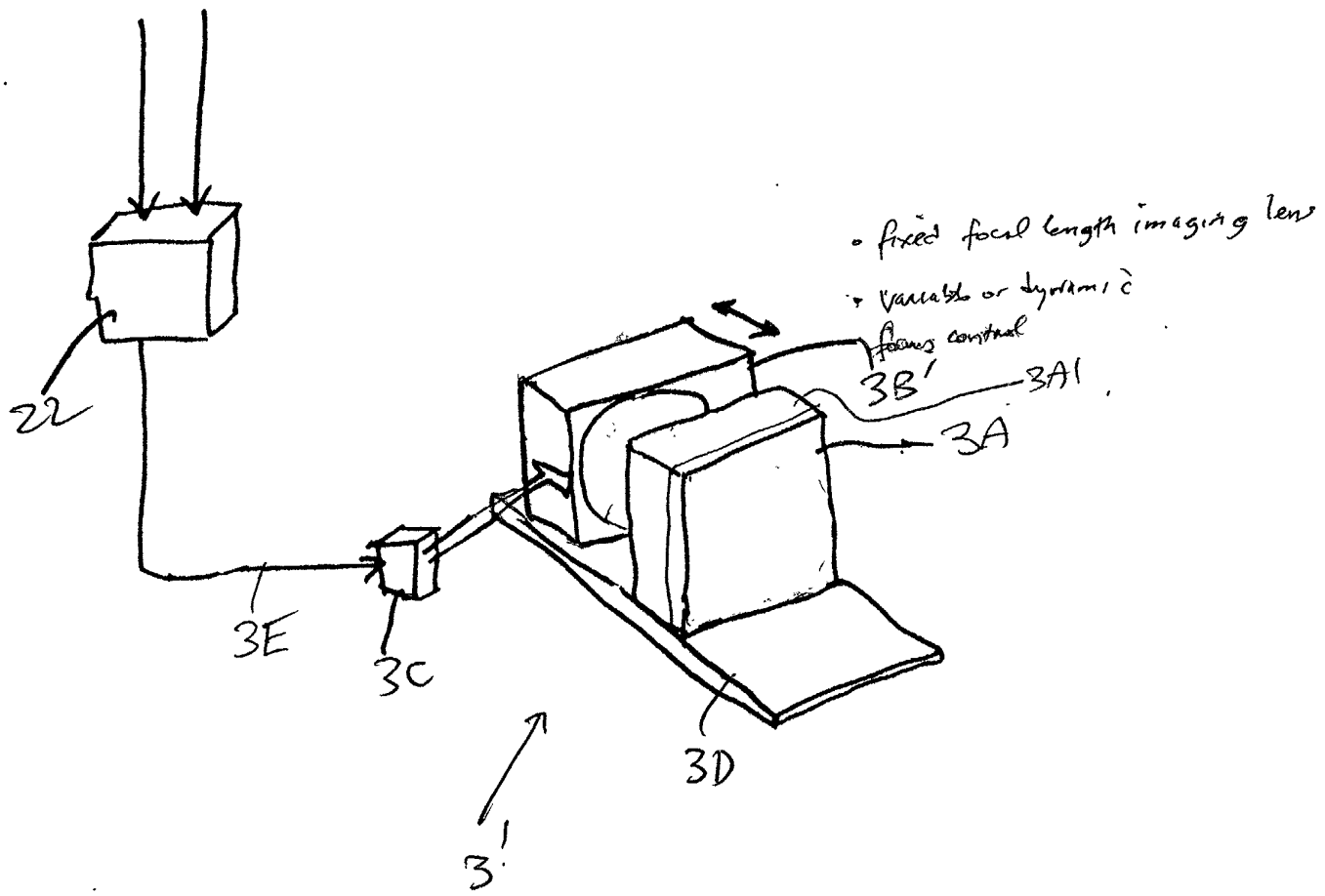

• fixed focal length imaging lens
• variable or dynamic focus control
22
3B'
3A1
3A
3E
3C
3D
3'

FIG. 2I4

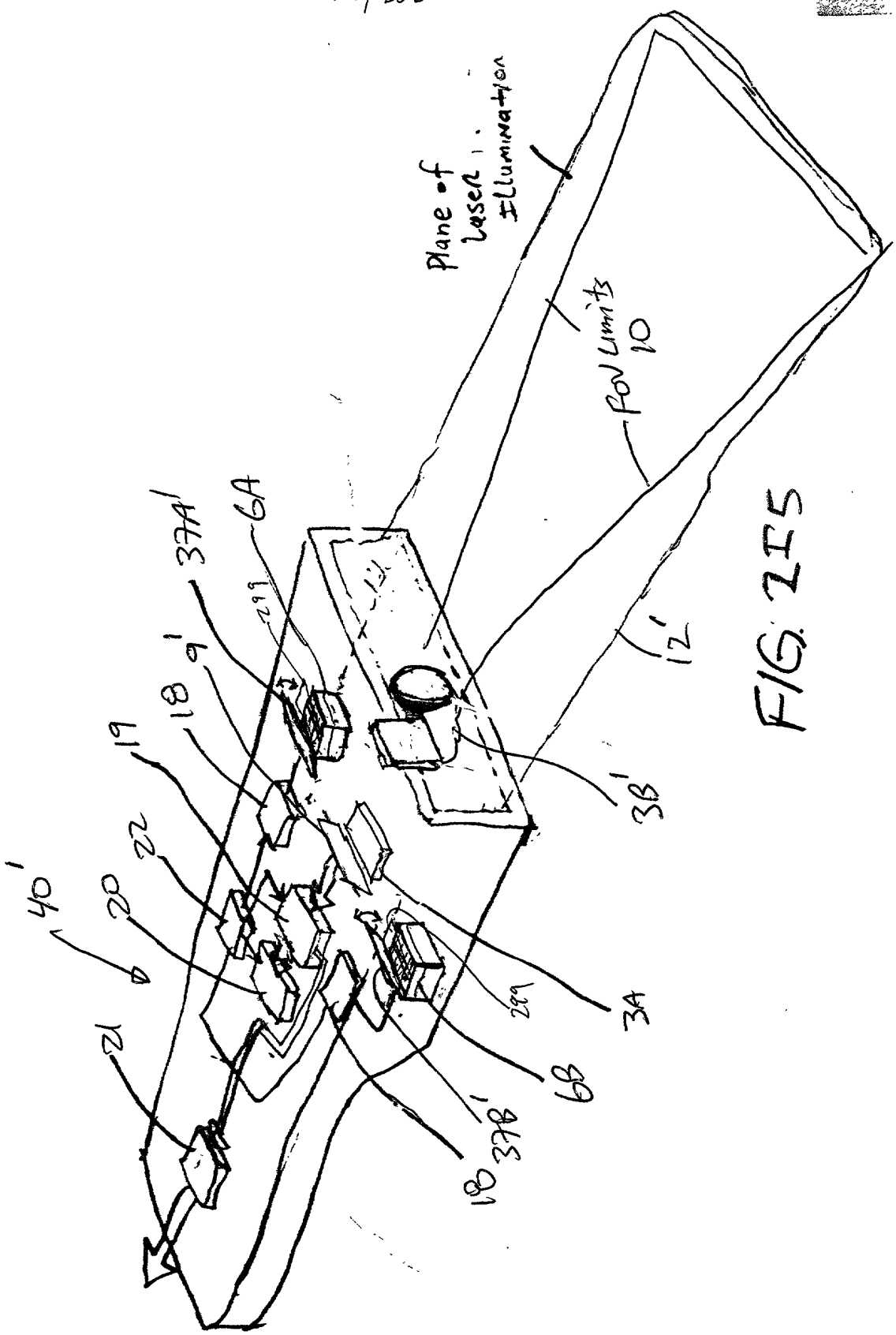

Plane of laser illumination
FOV Limits
10
12'
38'
6A
37A'
18'
19
22
20
40'
21
34
6B
37B'
18
29A'
29'

FIG. 11E

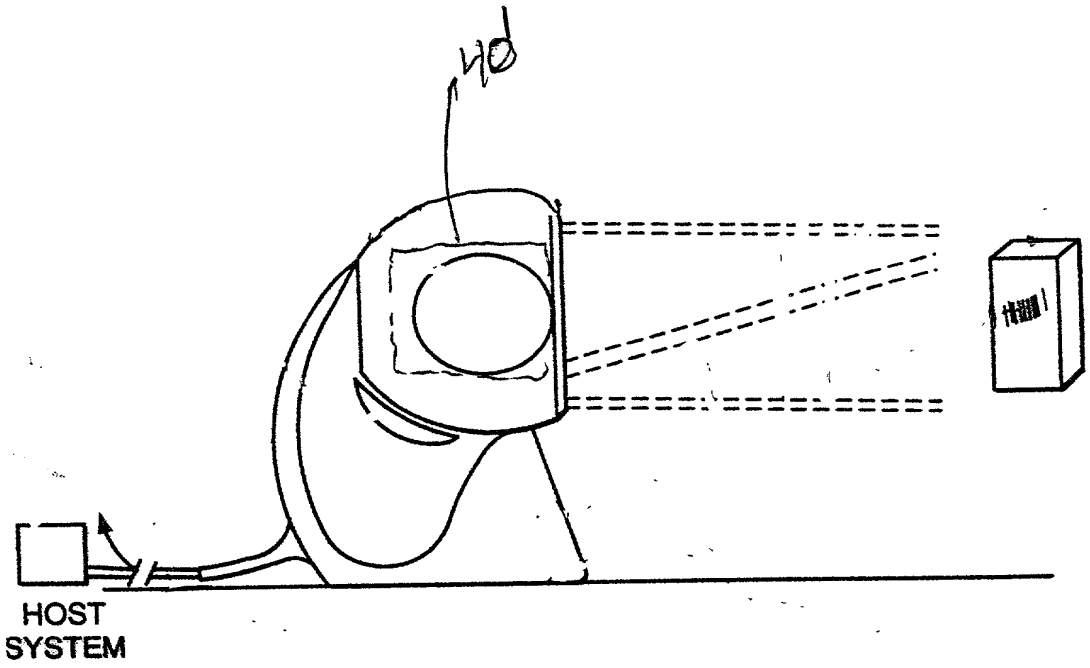


FIG. 2I6

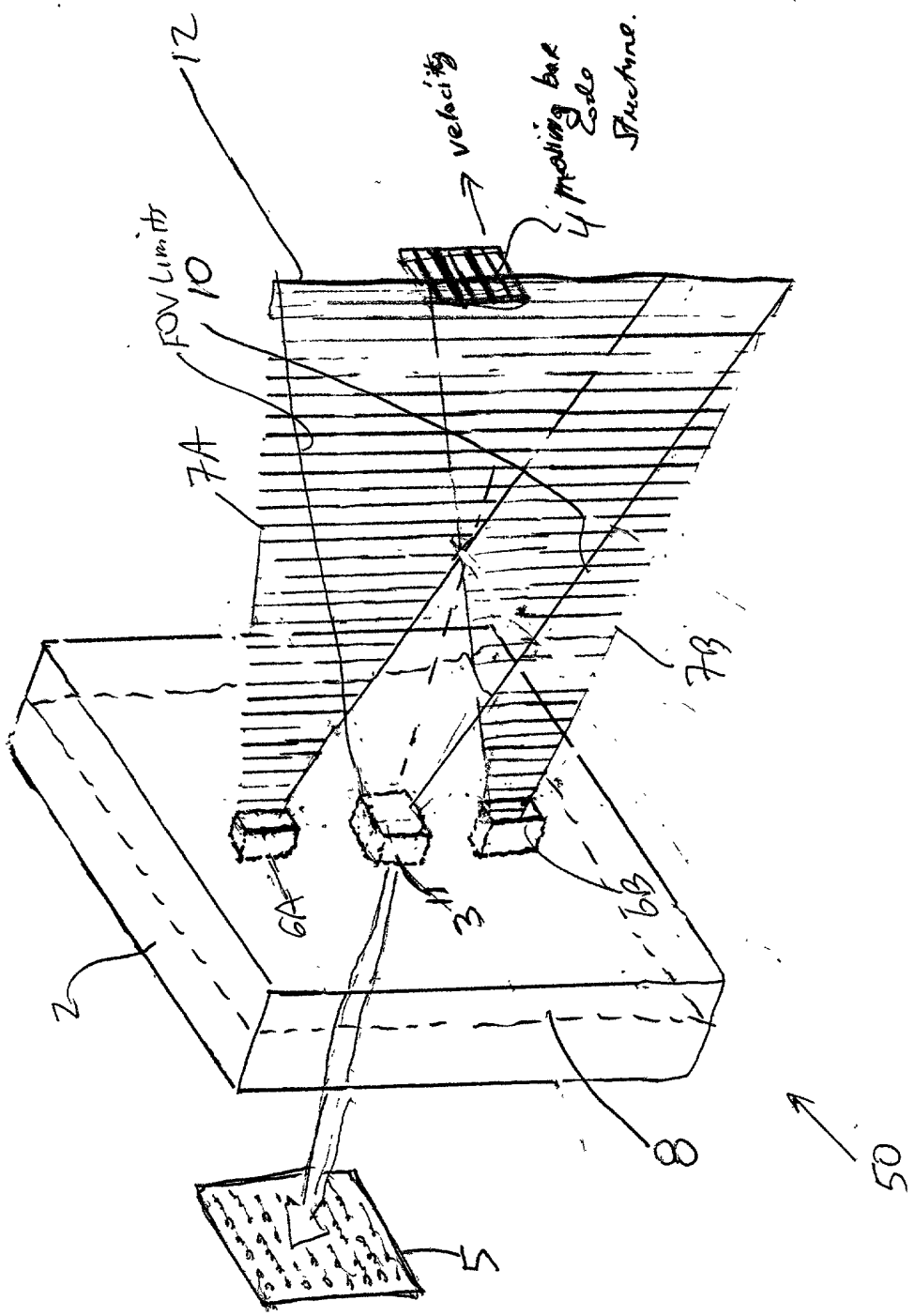

12
velocity
Moving bar
Edge
Structure.
FOV Limit
10
7A
7B
6A
6B
3
2
8
5
50

FIG 3A

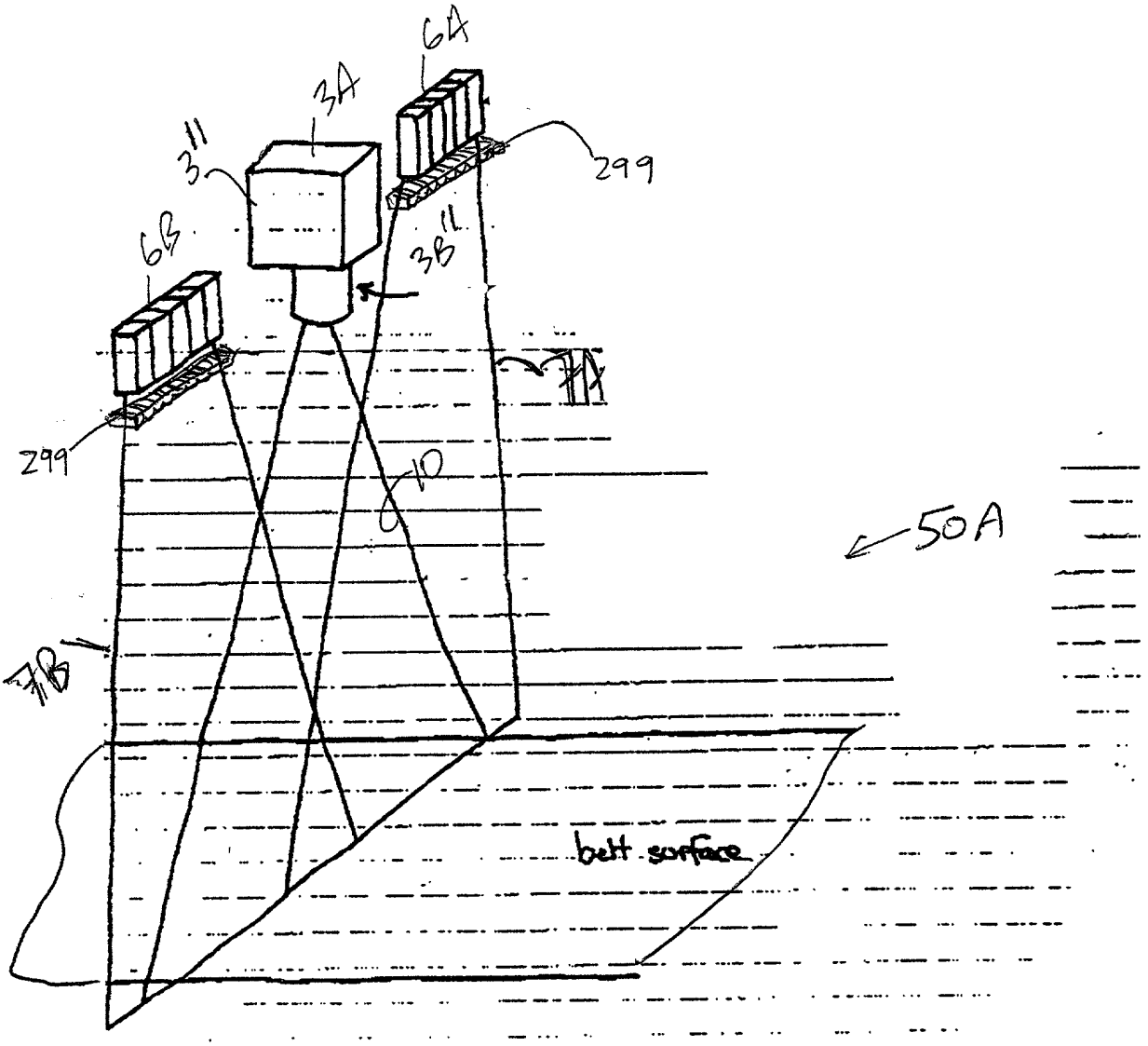


FIG. 3B1

(1) Variable focal length camera lens
(2) variable focal distance

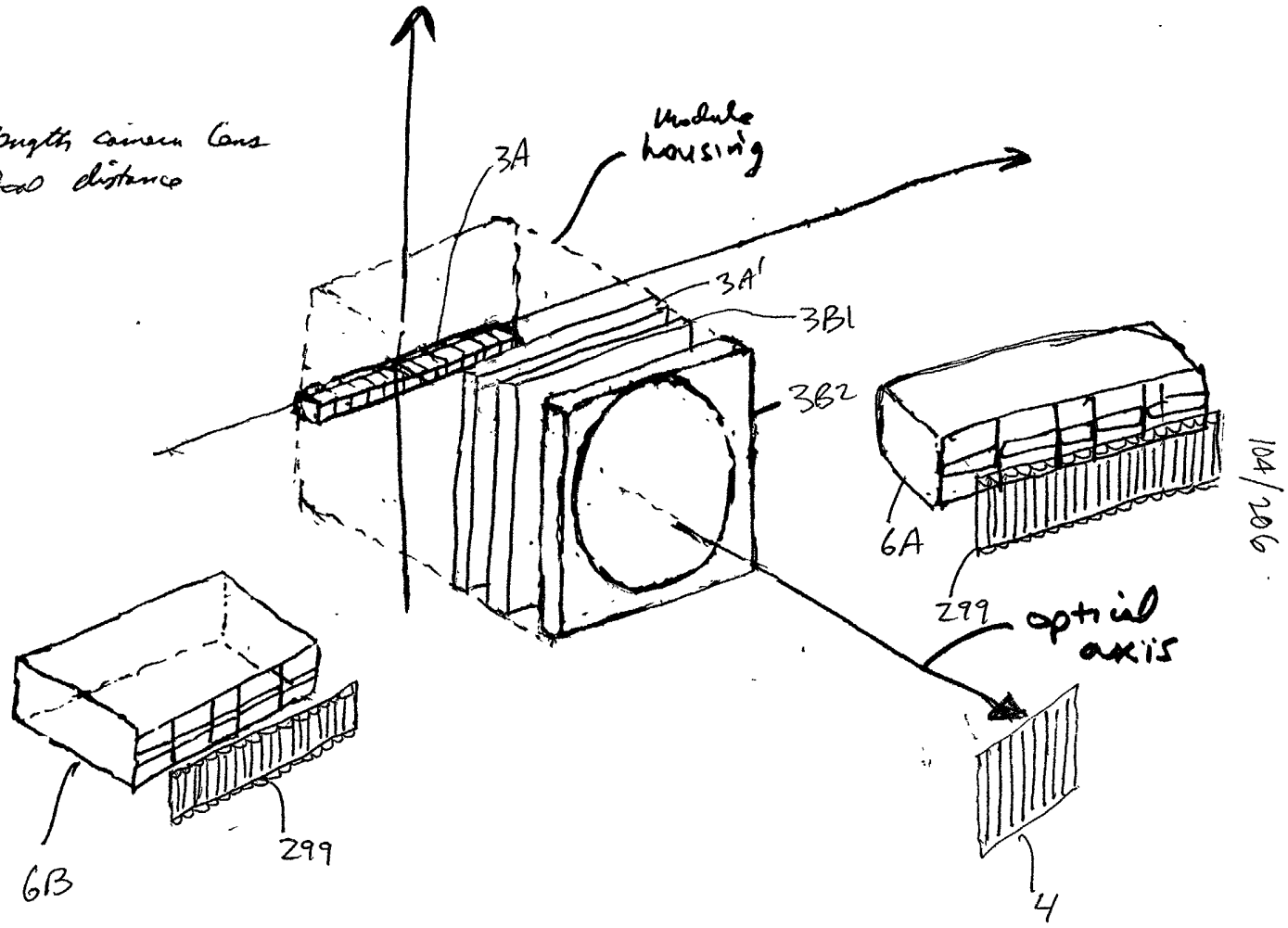


FIG. 3B2

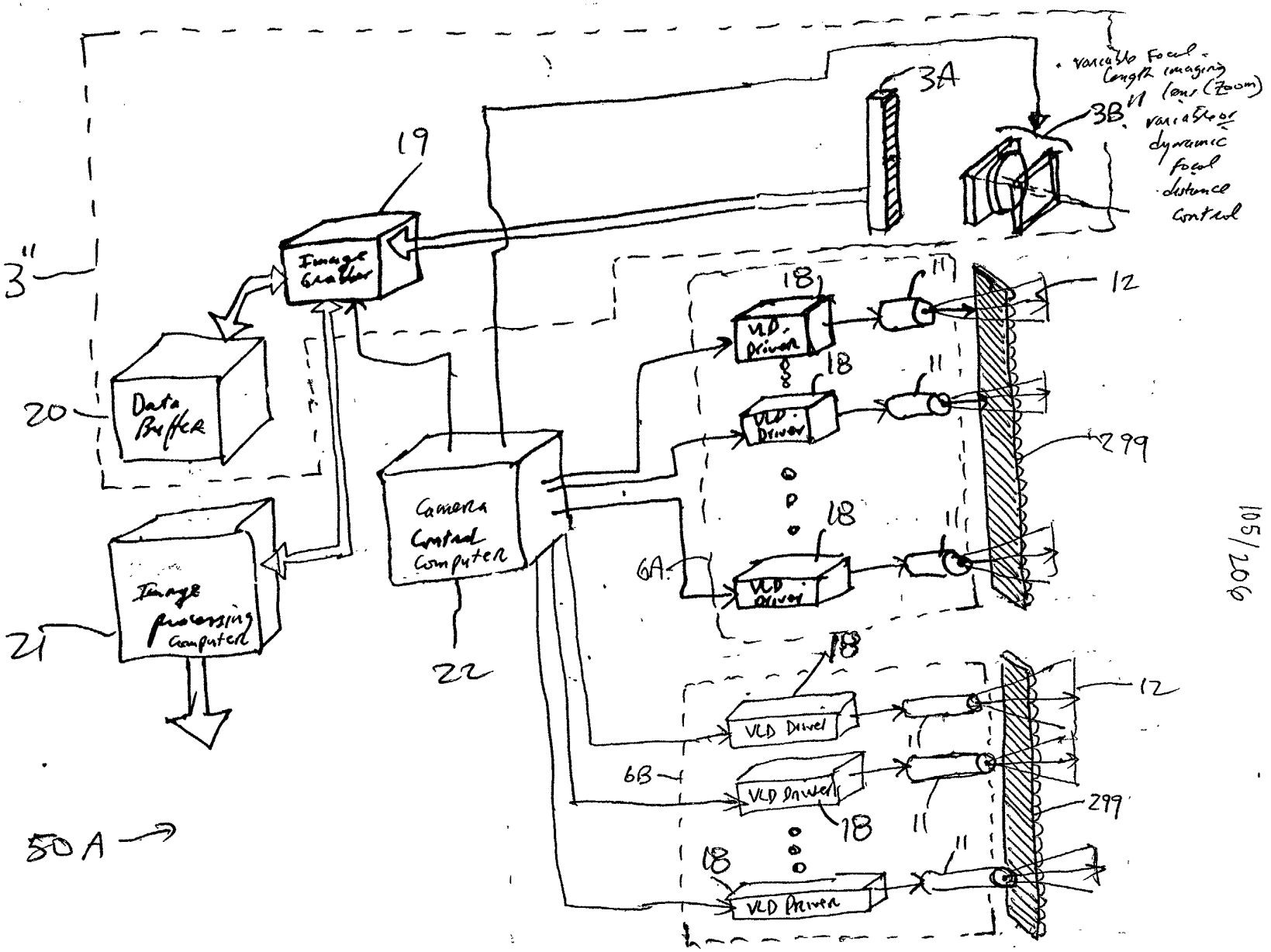
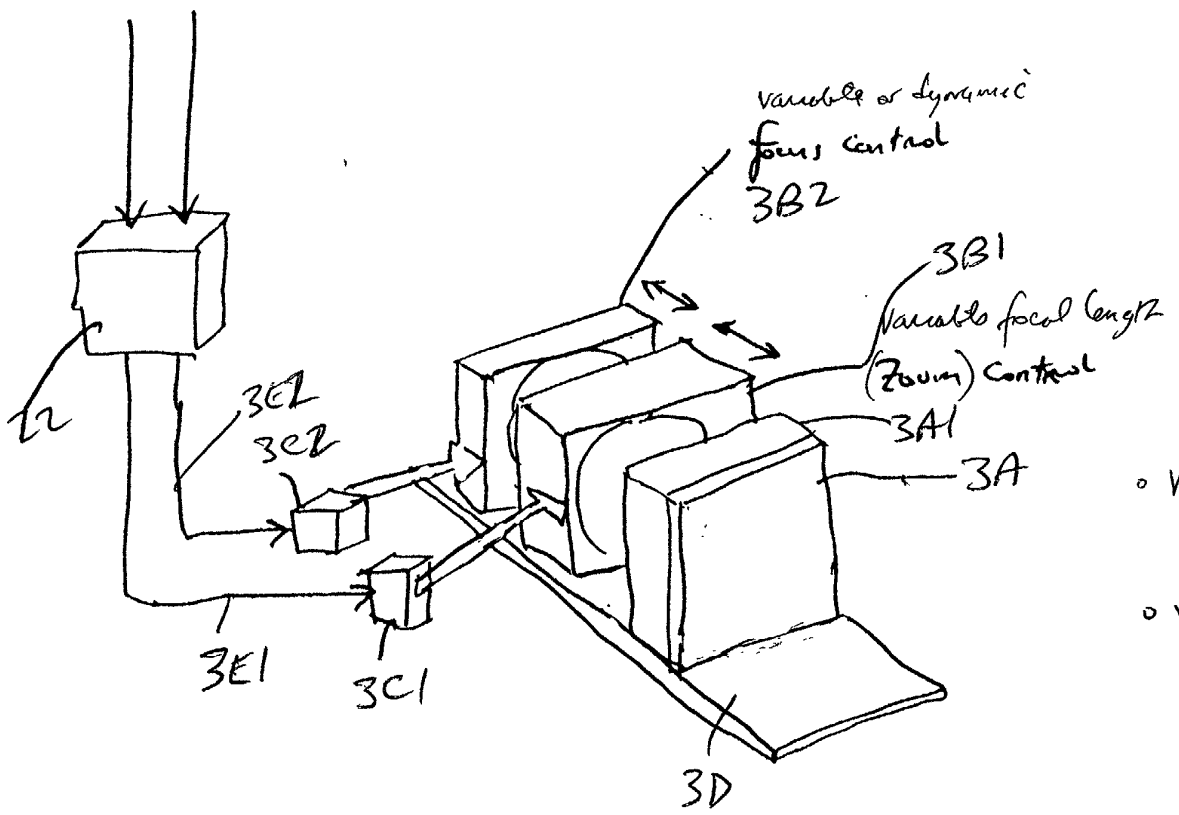


FIG 3C1



- variable focal length camera lens
- variable focal distance

FIG. 3C2

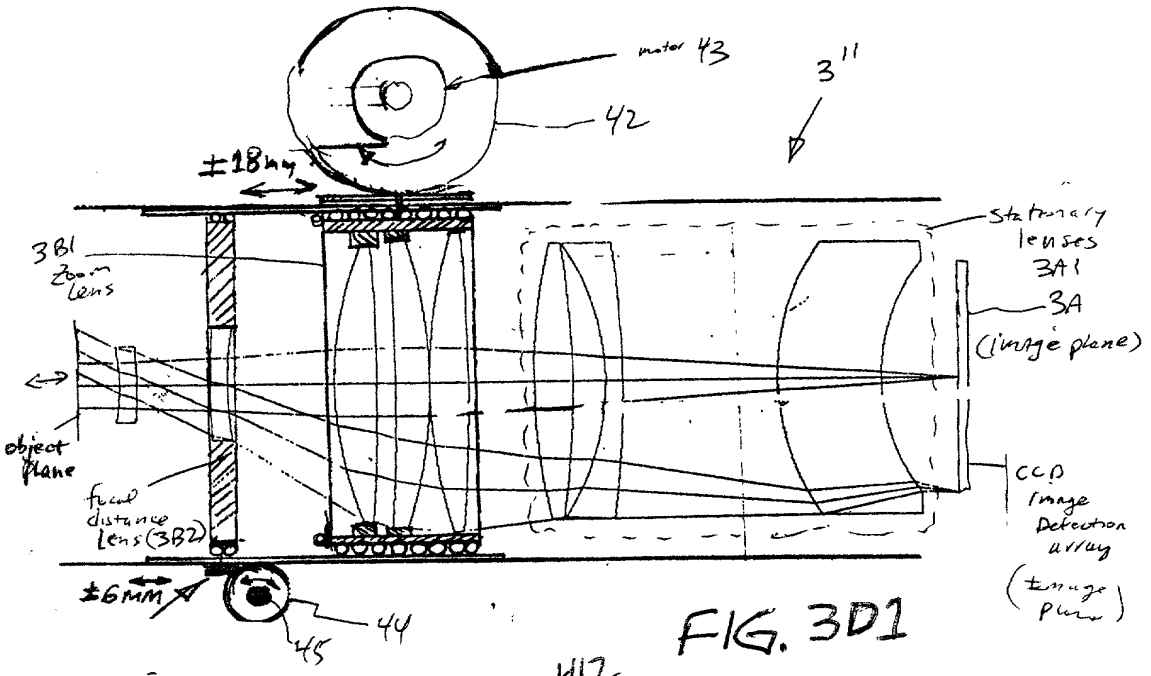


FIG. 3D1

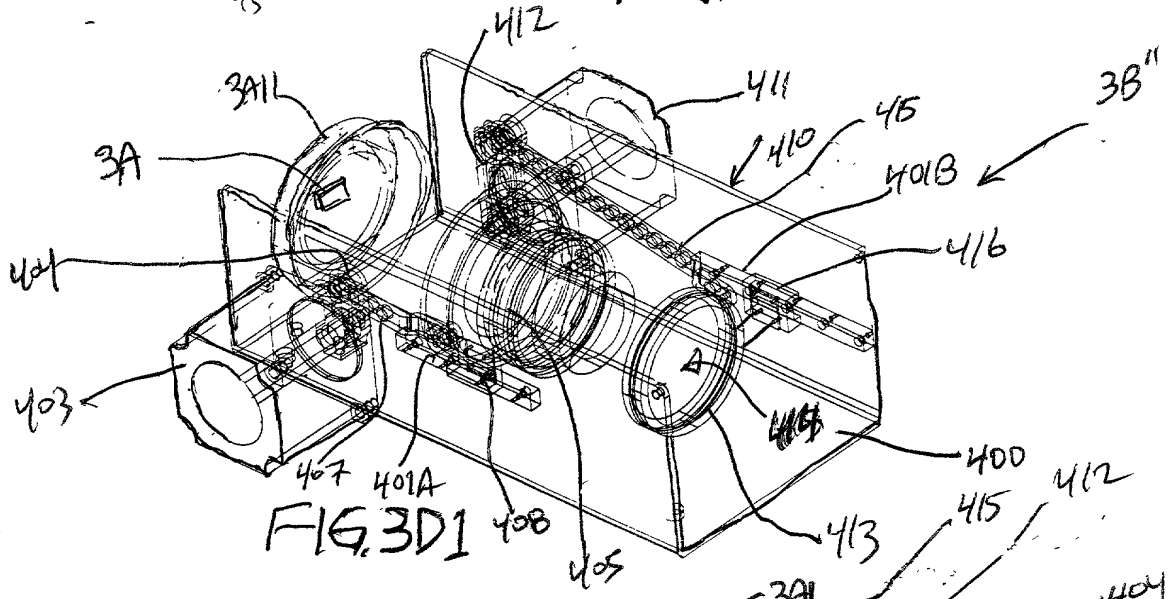


FIG. 3D1

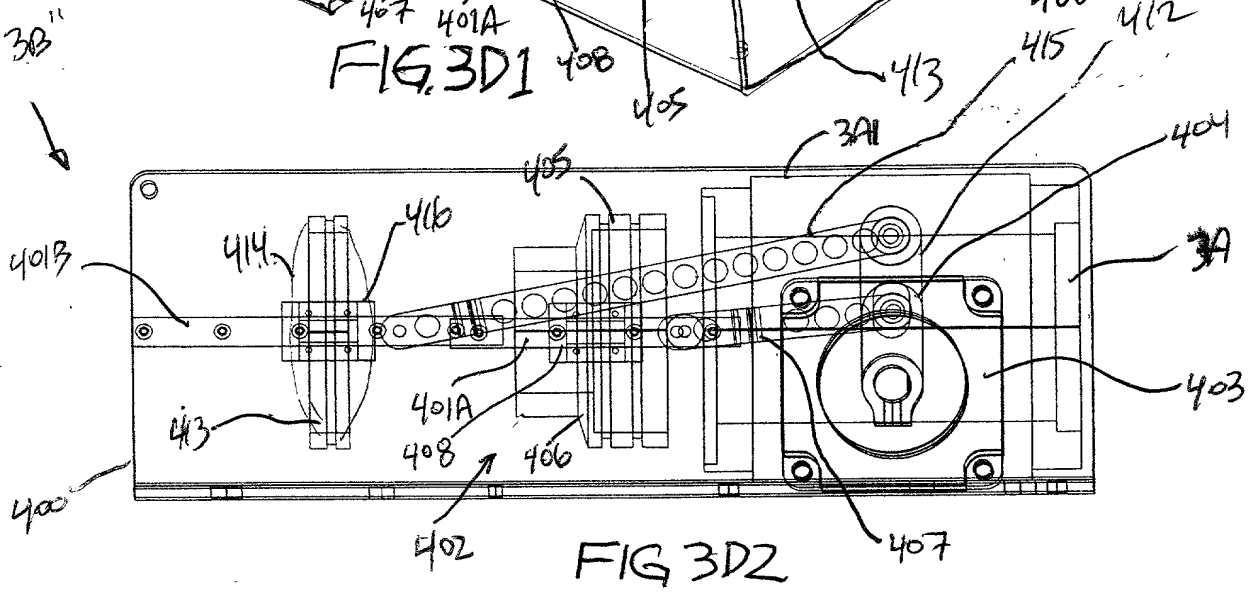


FIG 3D2

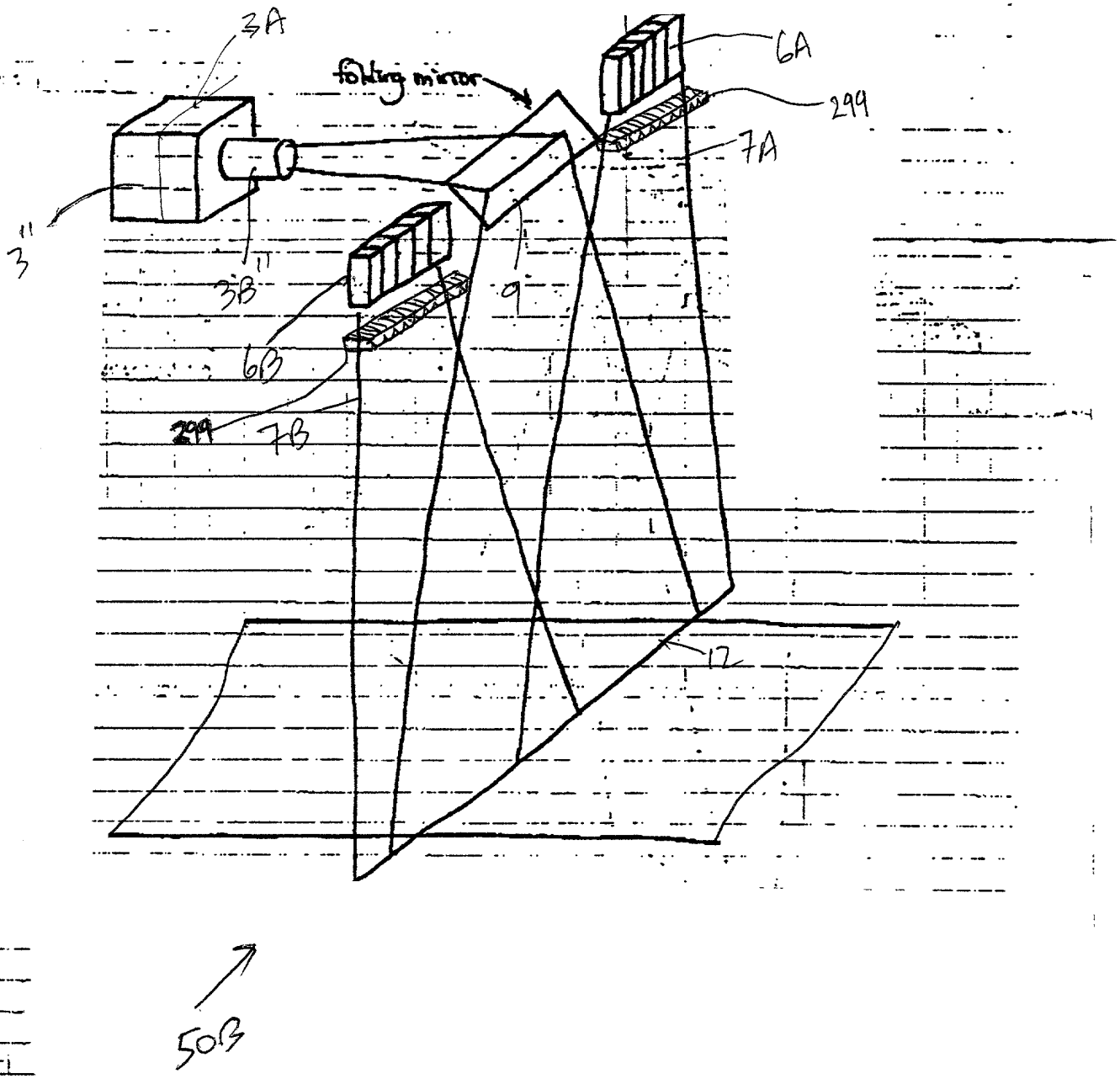


FIG. 3E1

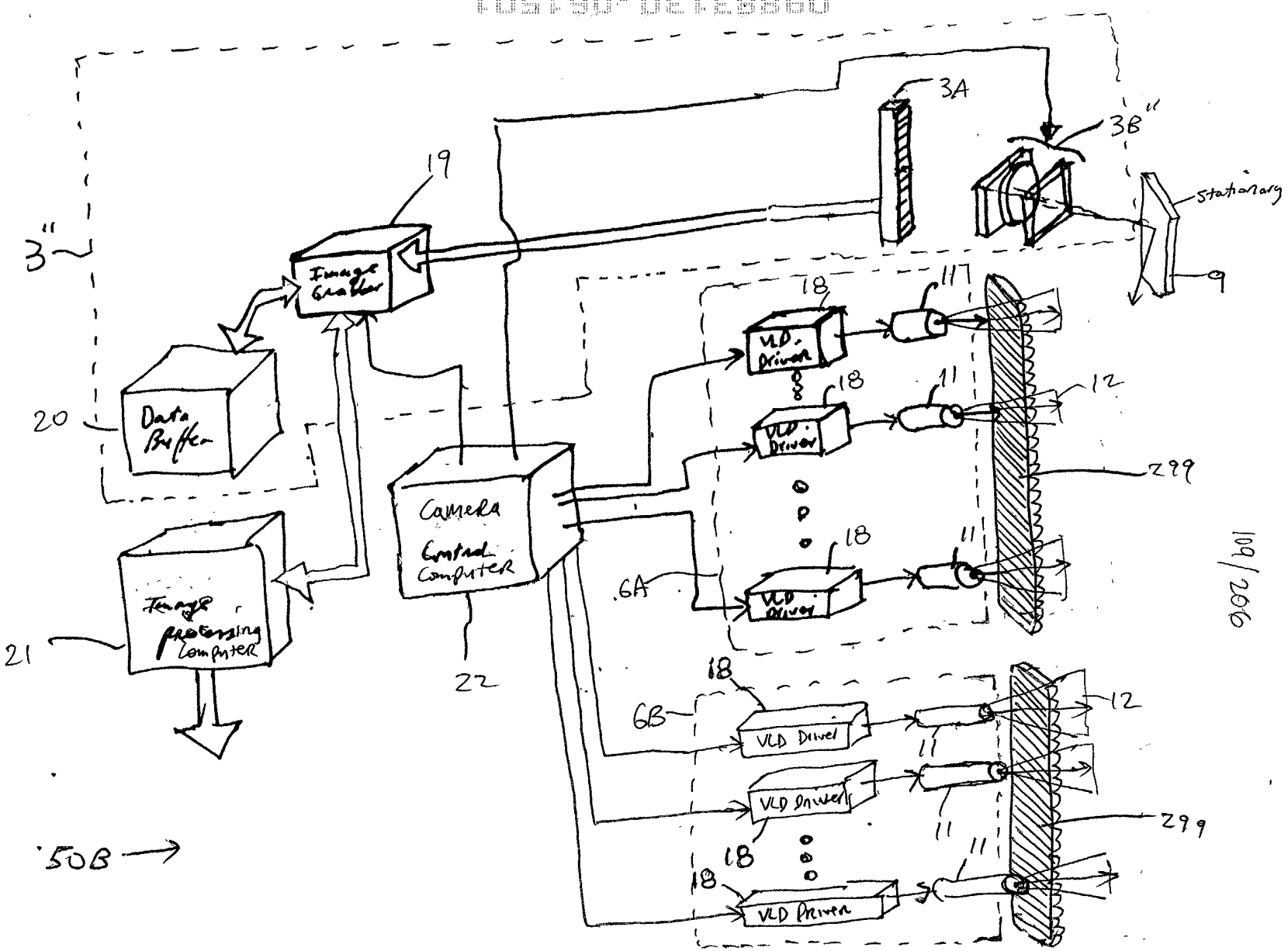


FIG. 3E2

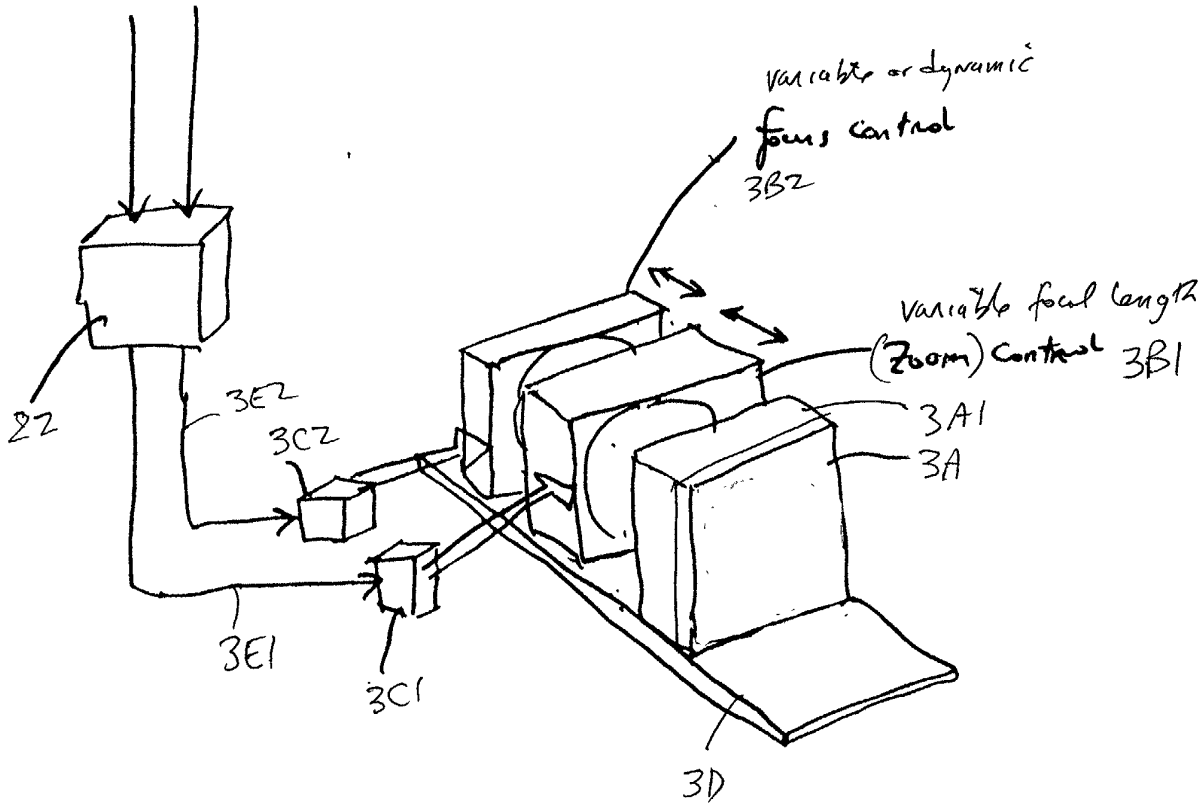

variable or dynamic
focus control
3B2
variable focal length
(zoom) control
3B1
3A1
3A
22
3E2
3C2
3E1
3C1
3D
3'1

FIG. 3E3

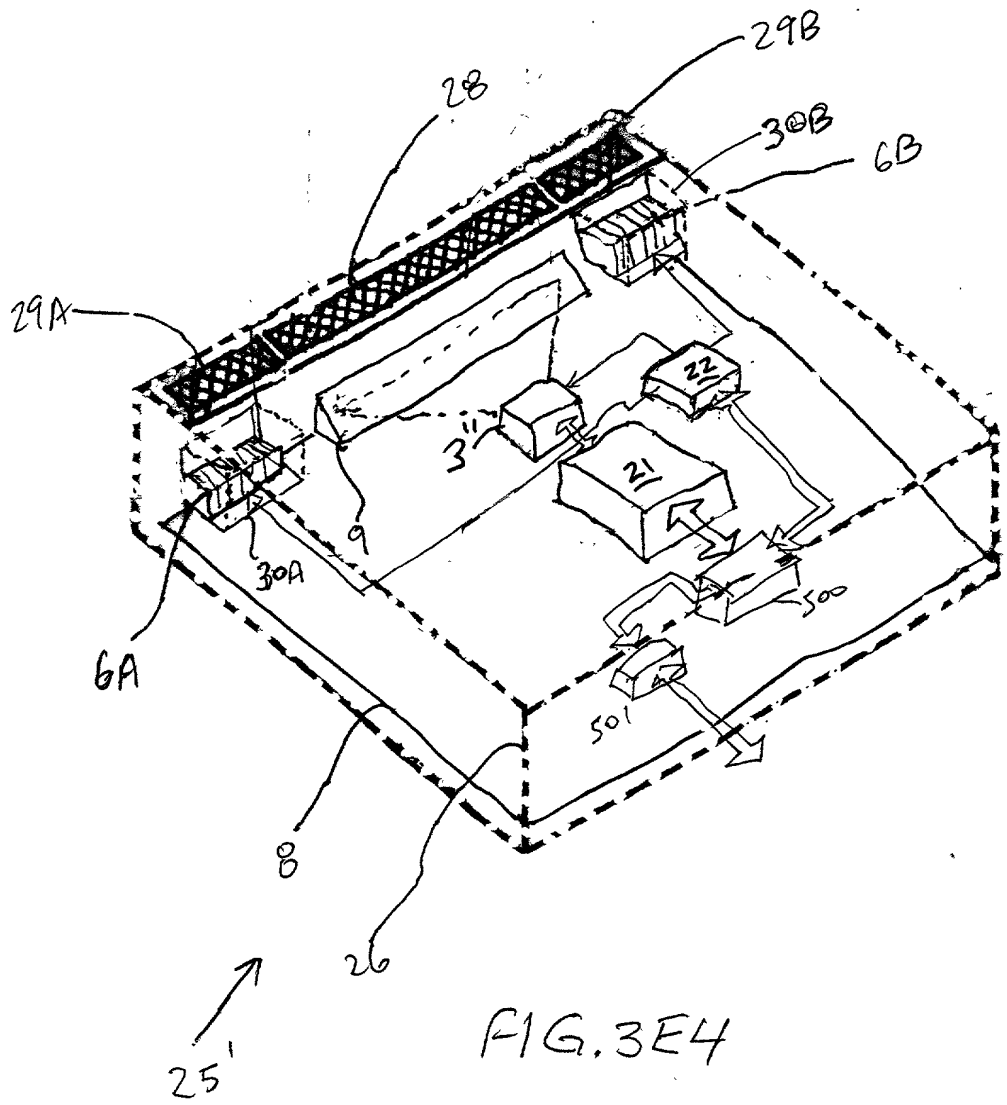


FIG. 3E4

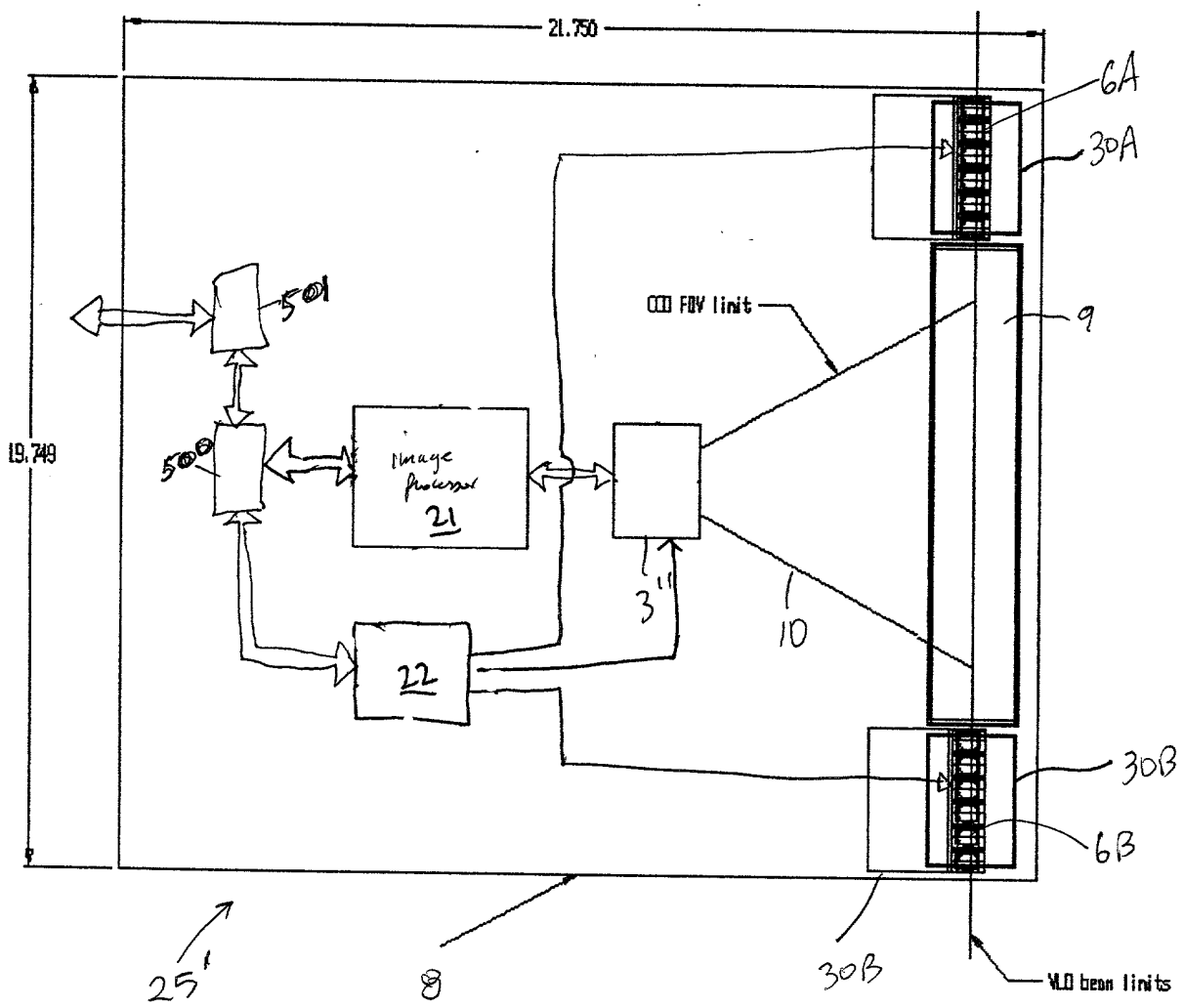

21.750
19.749
6A
30A
CCD FOV limit
9
501
500
Image processor
21
22
3''
10
30B
6B
25'
8
30B
VLD beam limits

FIG. 3E5

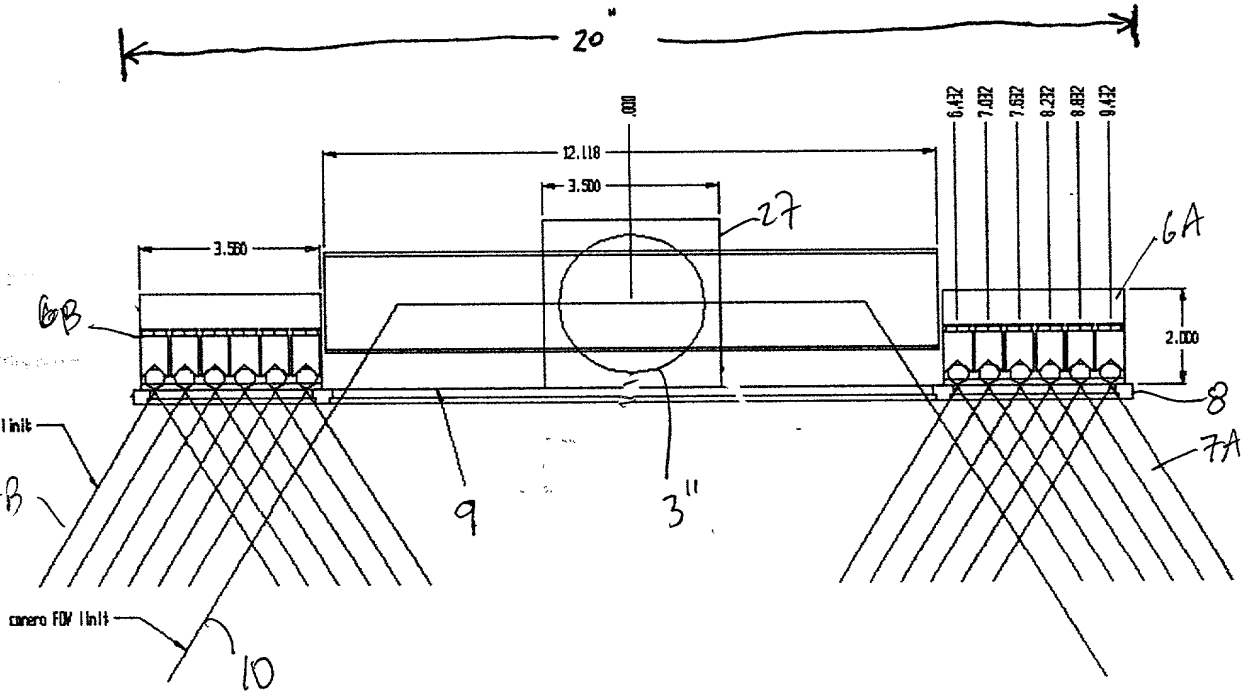

20"
.000
6.432
7.032
7.632
8.232
8.832
9.432
12.118
3.500
3.500
27
6A
6B
2.000
8
7A
7B
9
3"
10
camera FOV limit

FIG. 3E6

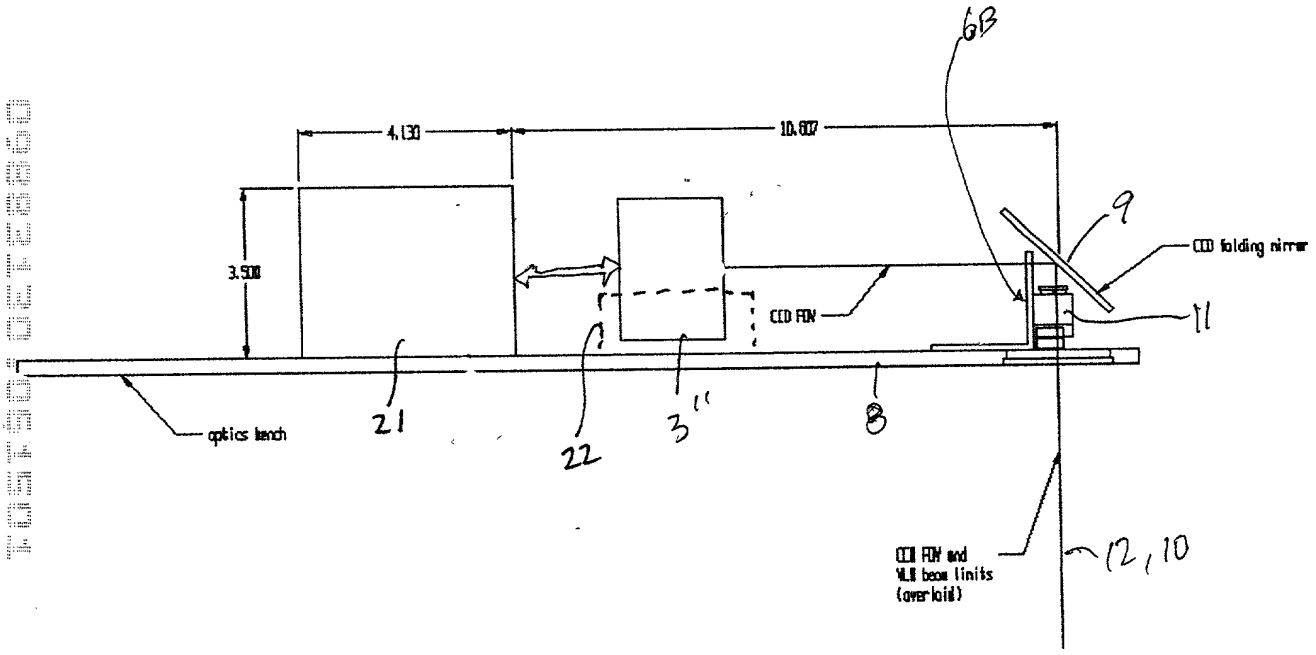

6B
4.130
10.607
9
CCD folding mirror
3.500
CCD FPA
11
optics bench
21
22
3"
8
CCD FPA and
YAG beam limits
(overlaid)
12, 10

FIG. 3E7

*variable FOV

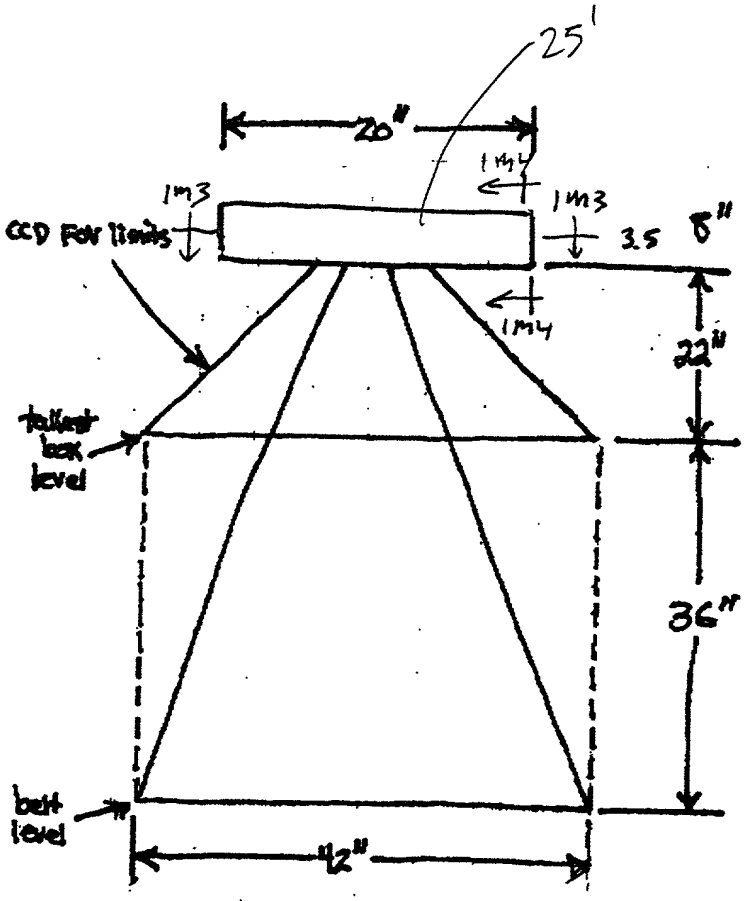


FIG. 3E8

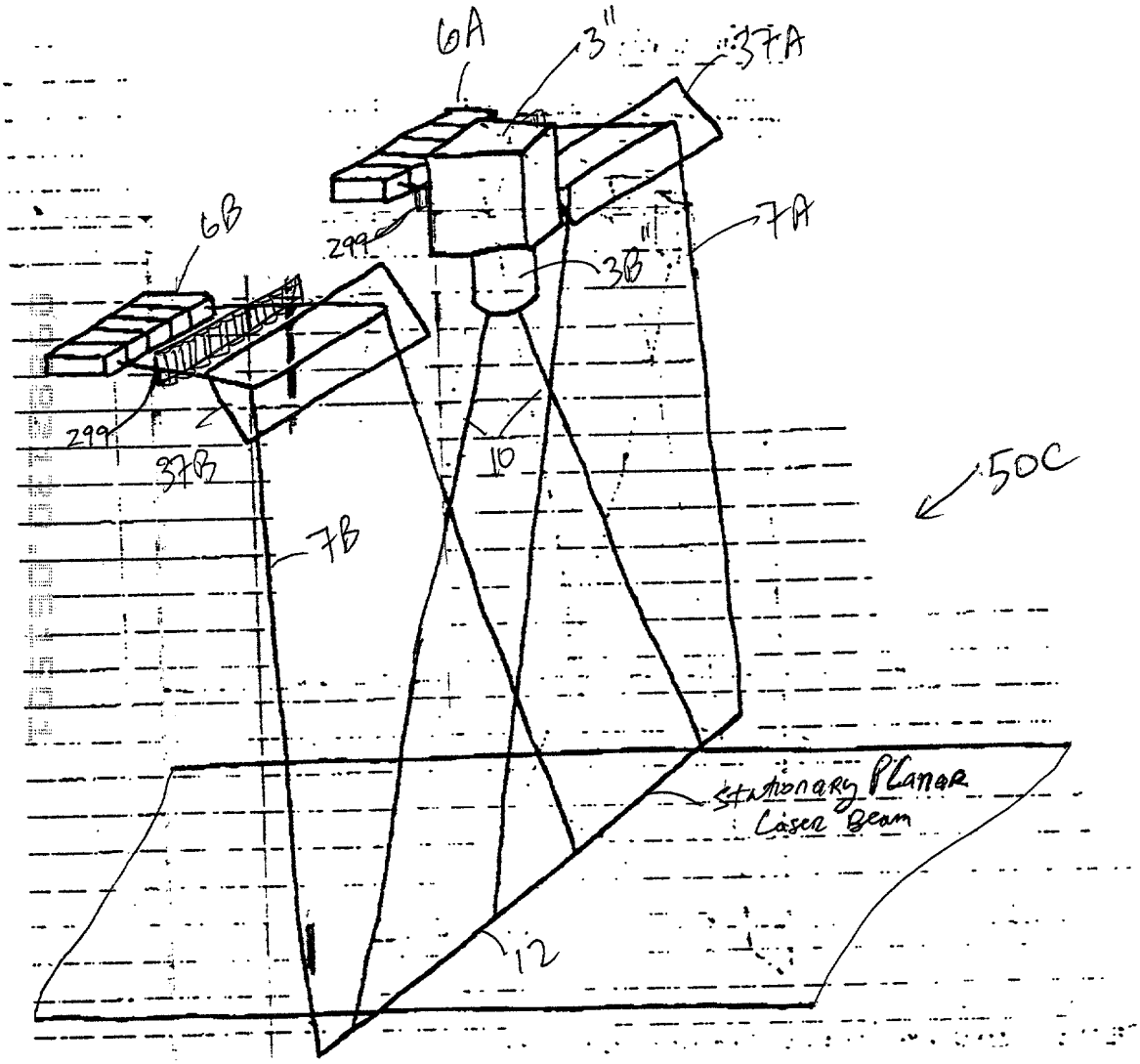

6A
3"
37A
6B
299
7A
38"
299
37B
10
50C
7B
Stationary Planar
Laser Beam
12

FIG. 3F1

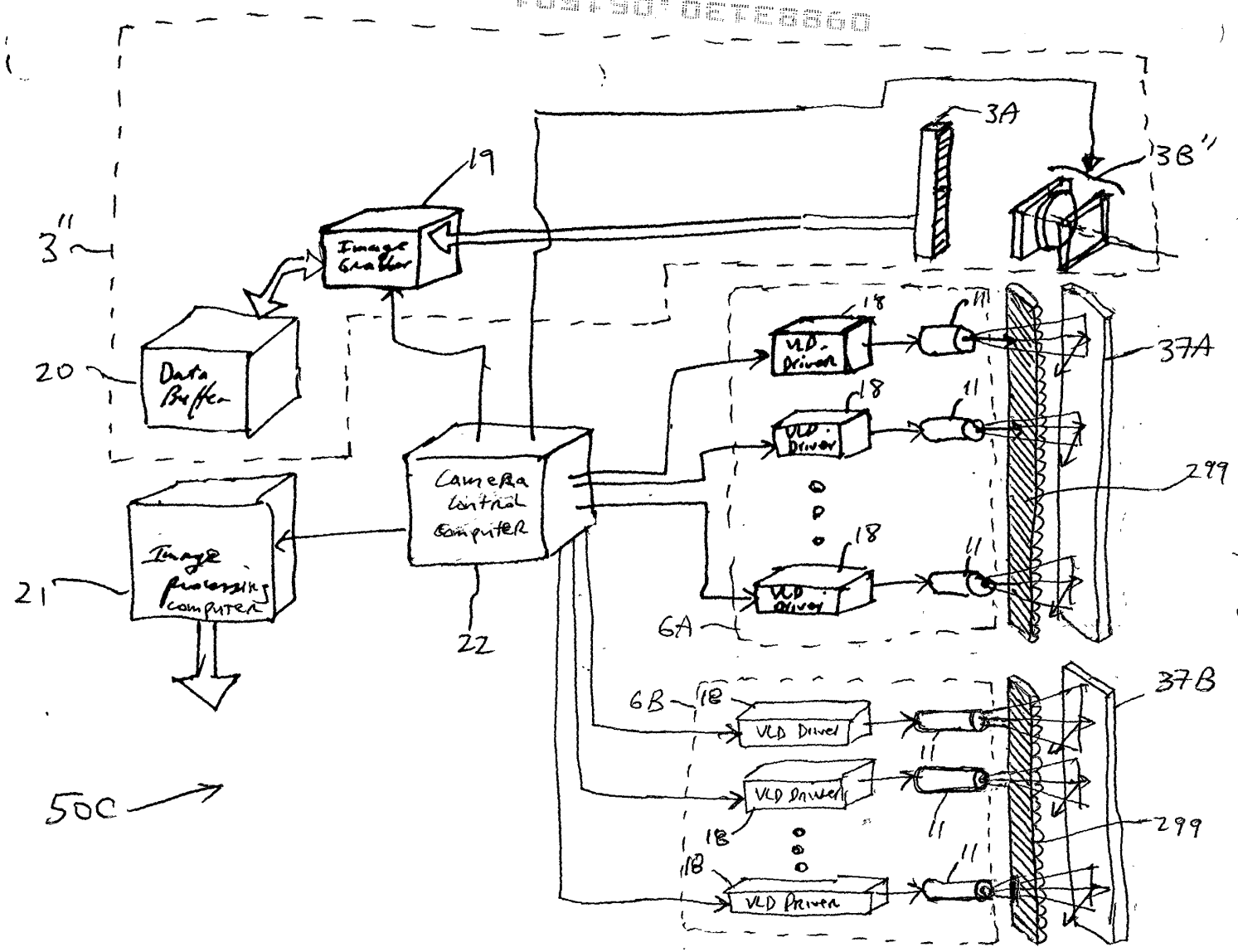
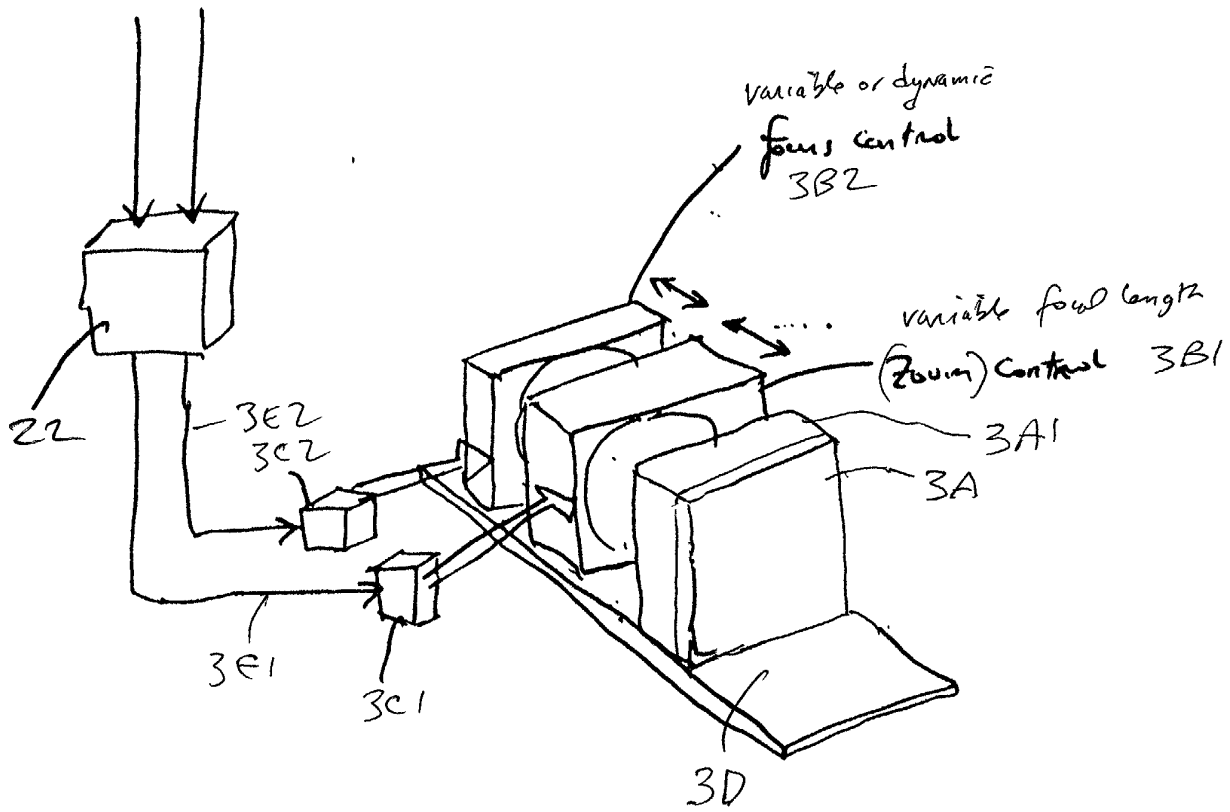

3'
19
Image Grabber
3A
3B'
20
Data Buffer
18
VLD Driver
11
37A
Camera Control Computer
299
21
Image processing computer
22
6A
37B
6B
VLD Driver
50C

FIG. 3F2



3''

FIG. 3F3

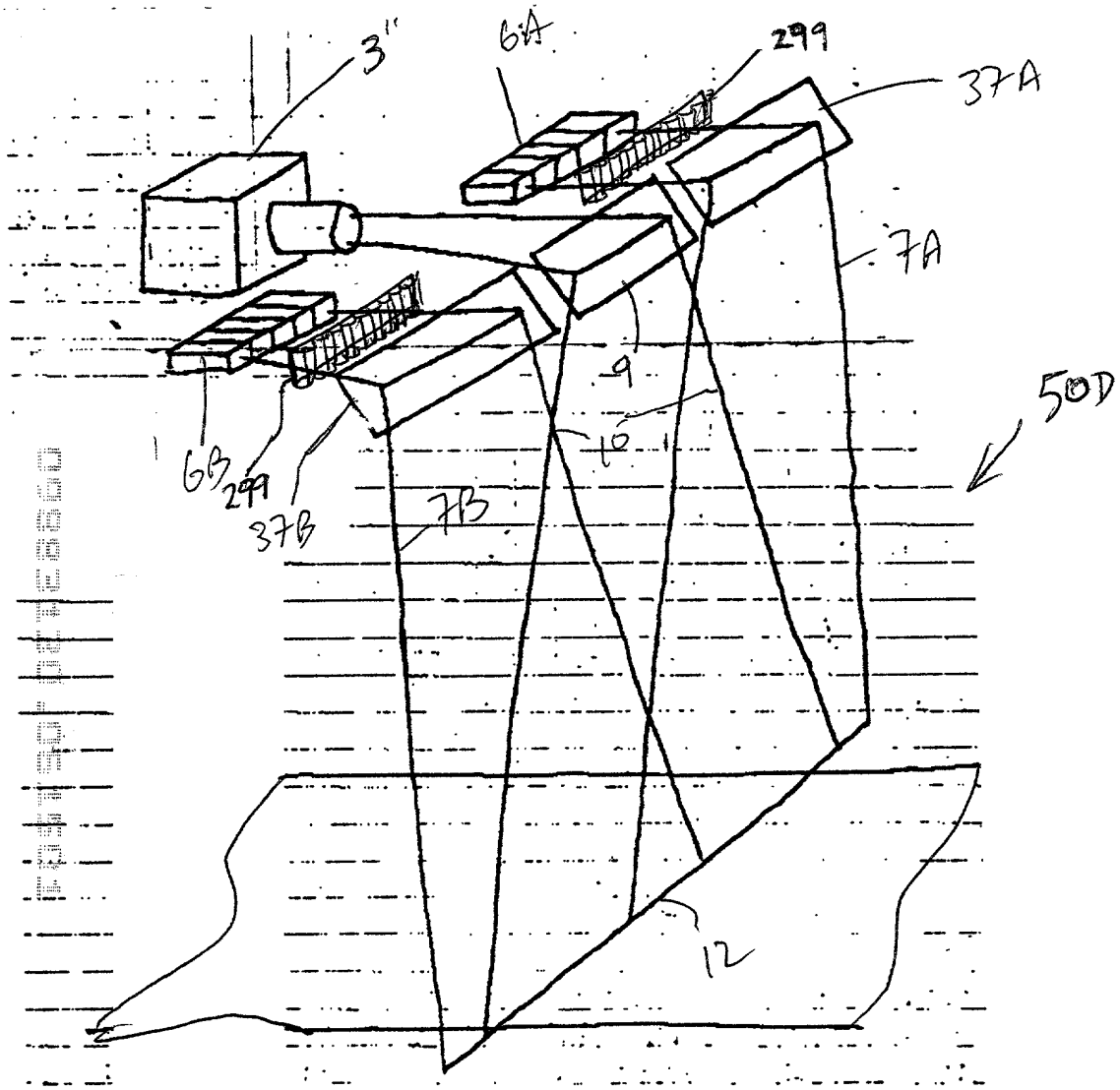


FIG. 3G1

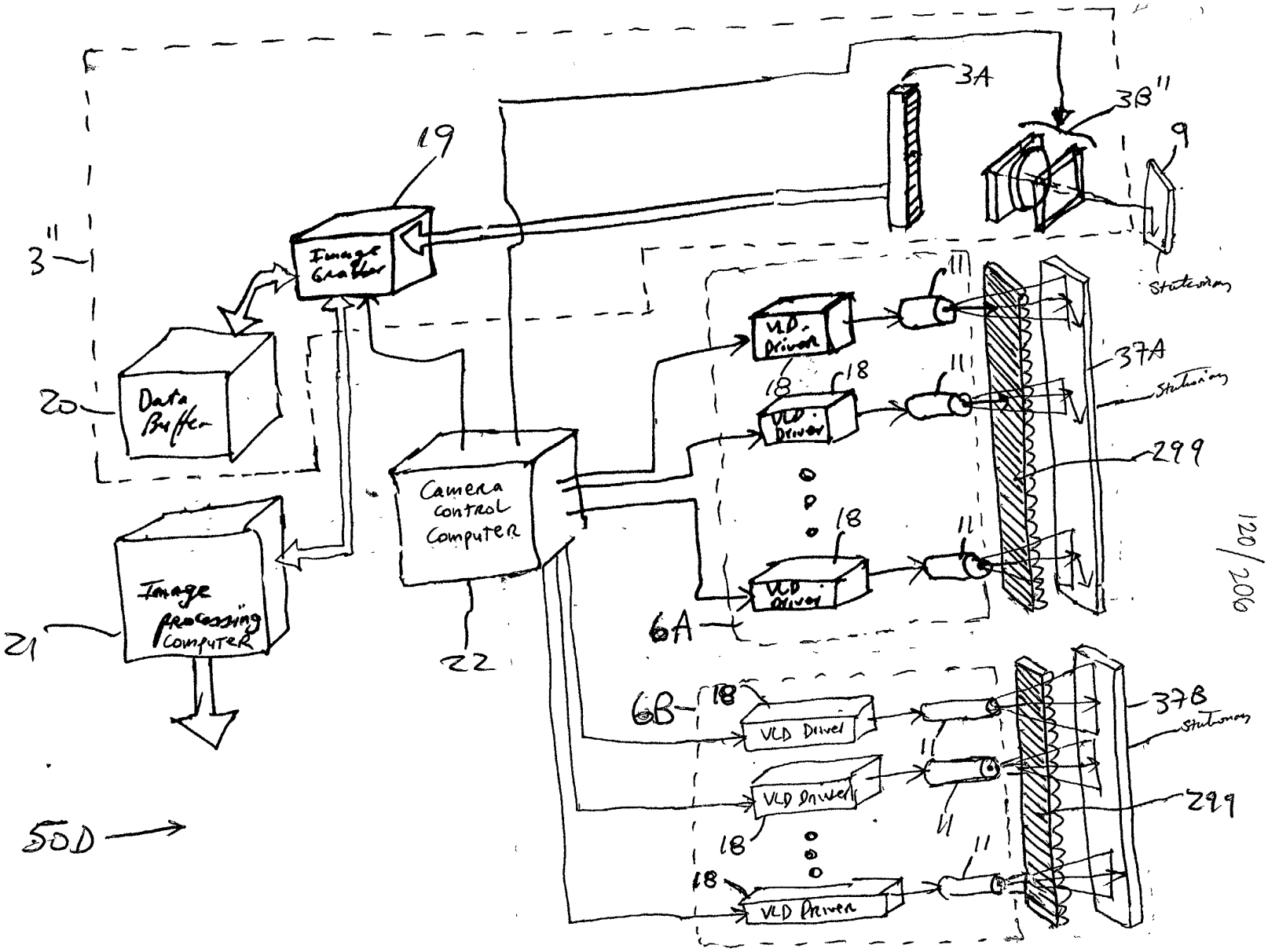

3A
3B''
9
19
3''
Image Grabber
Data Buffer
20
Camera control Computer
Image processing Computer
21
22
50D
VLD Driver
18
11
37A
299
6A
6B
37B
Stationary
120/206

FIG. 3G2

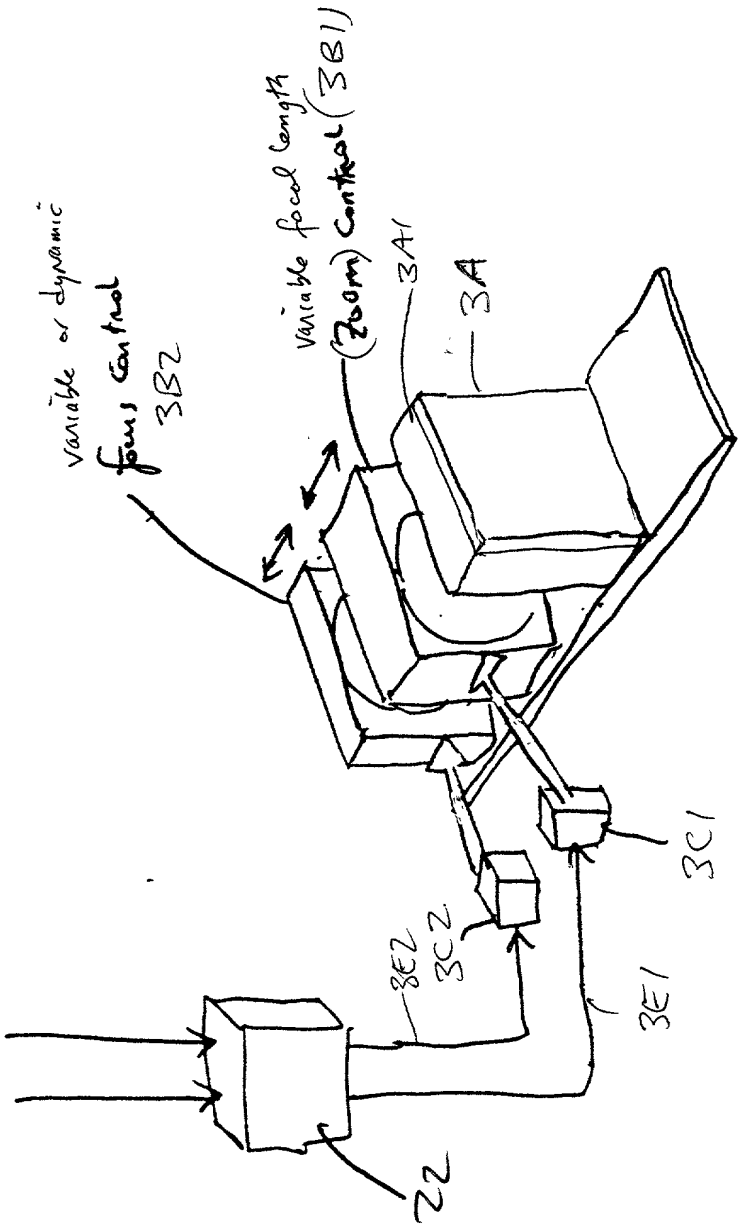

variable or dynamic
focus control
3B2
variable focal length
(zoom) control (3B1)
3A1
3A
3C1
3C2
3E2
3E1
22
3''

FIG 3G3

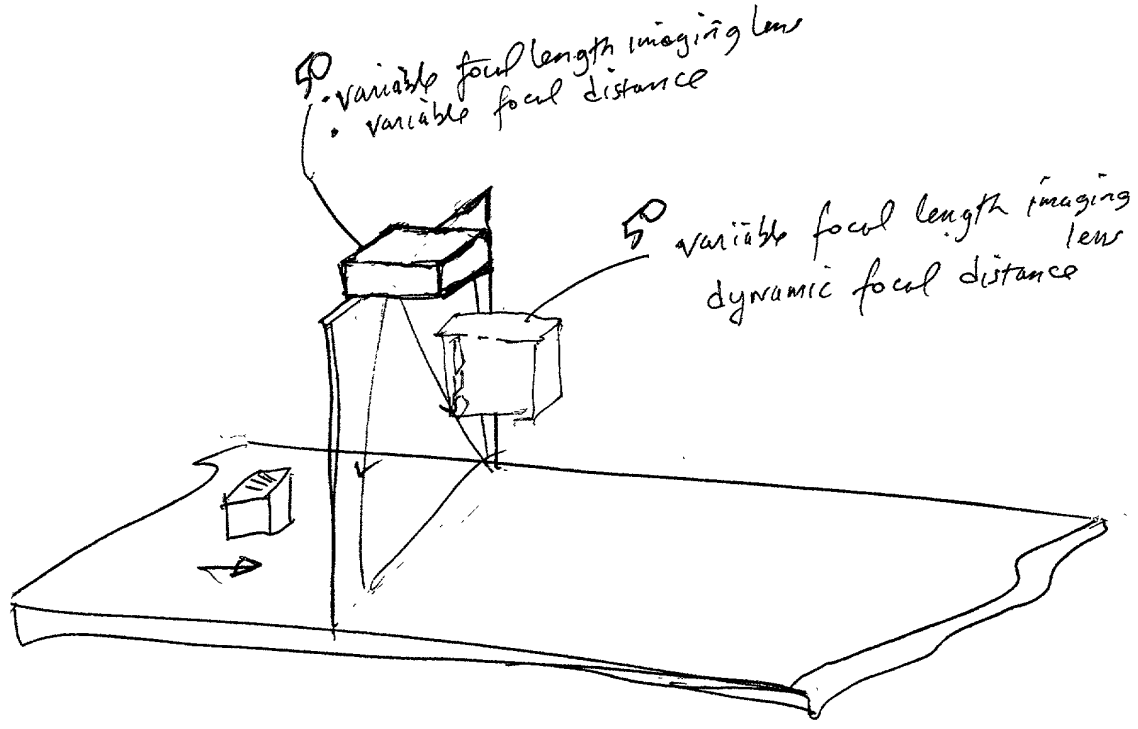

variable focal length imaging lens
• variable focal distance
variable focal length imaging lens
dynamic focal distance

FIG. 3H

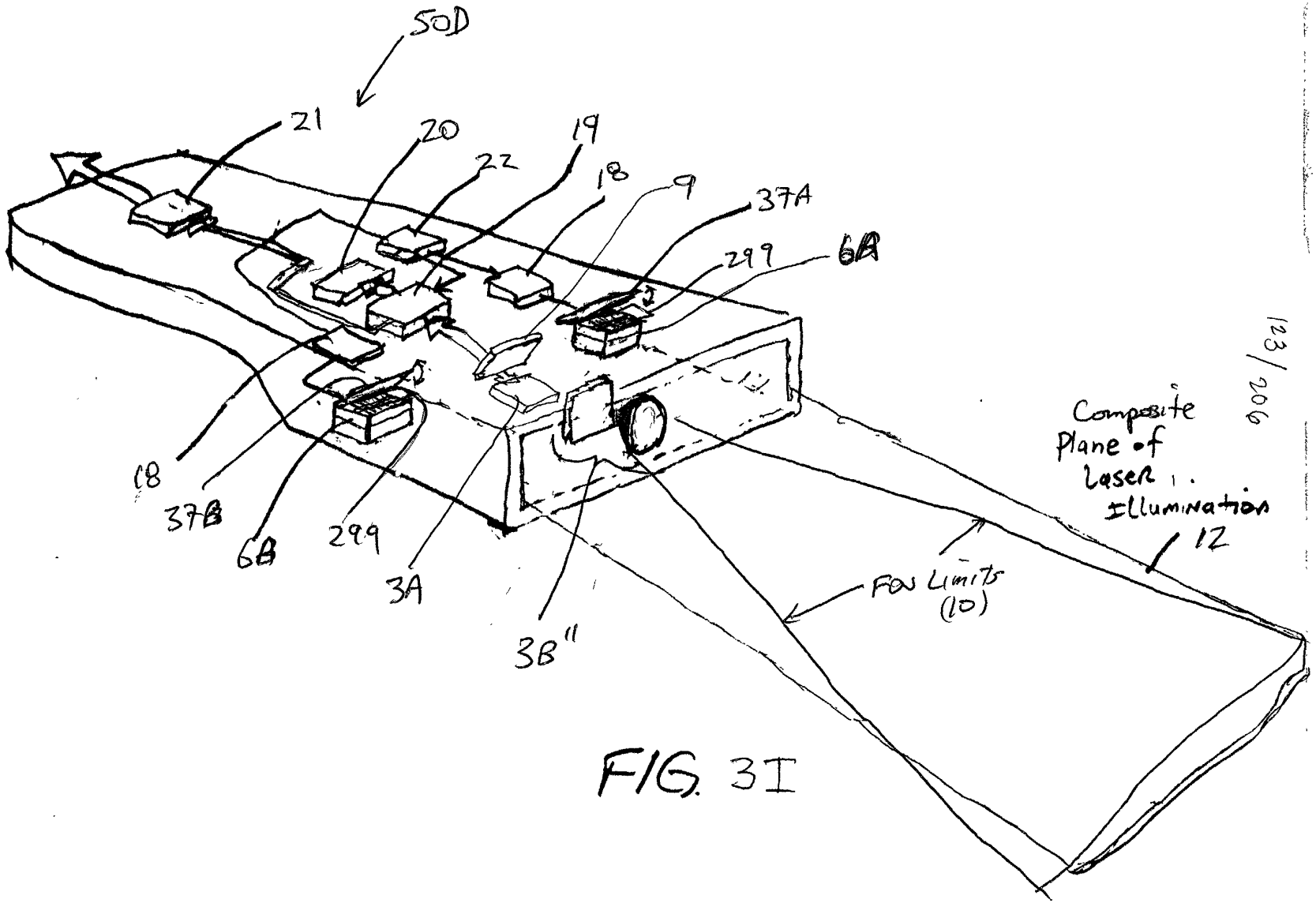


FIG. 3I

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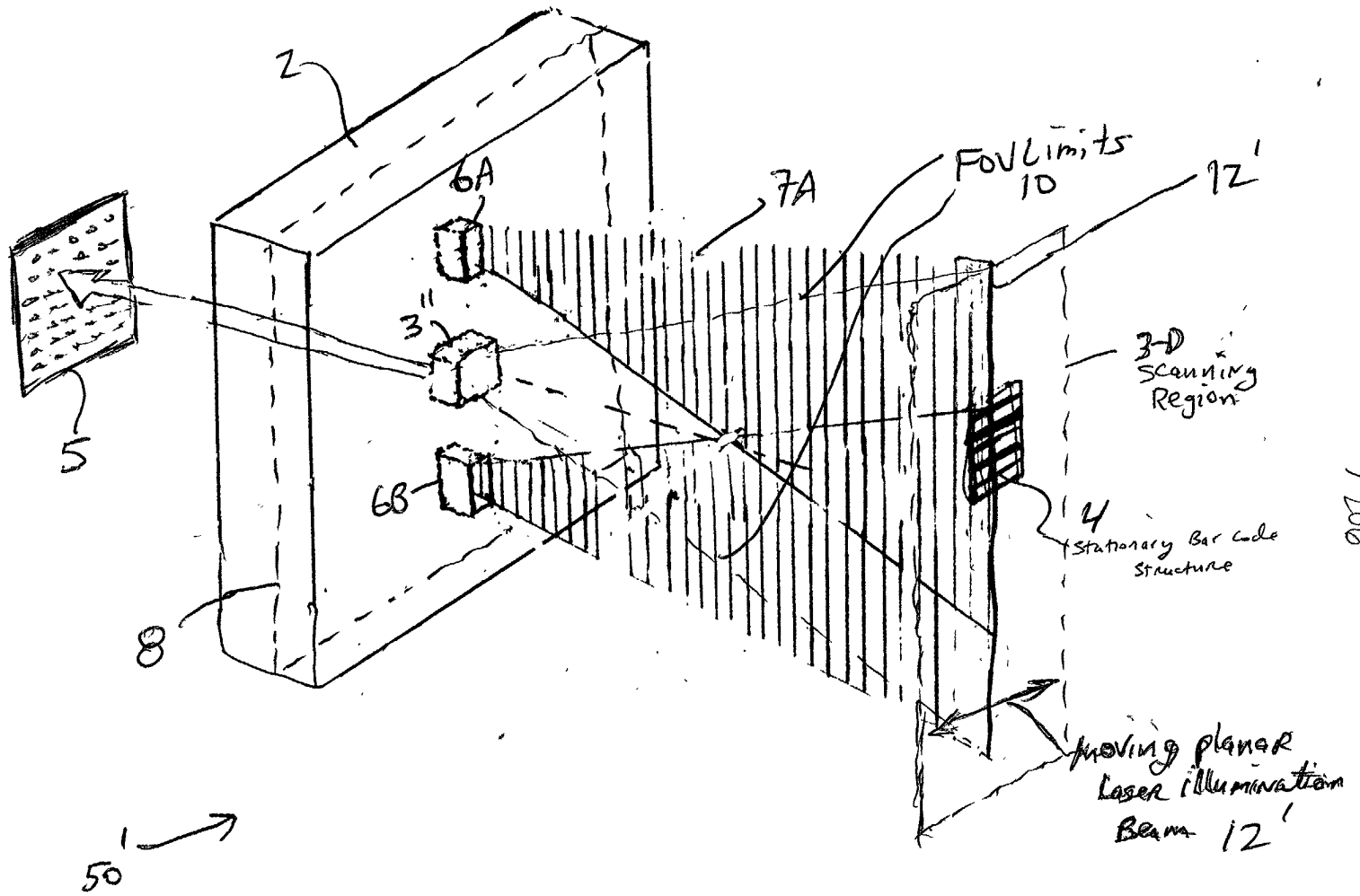

FIG. 3J1

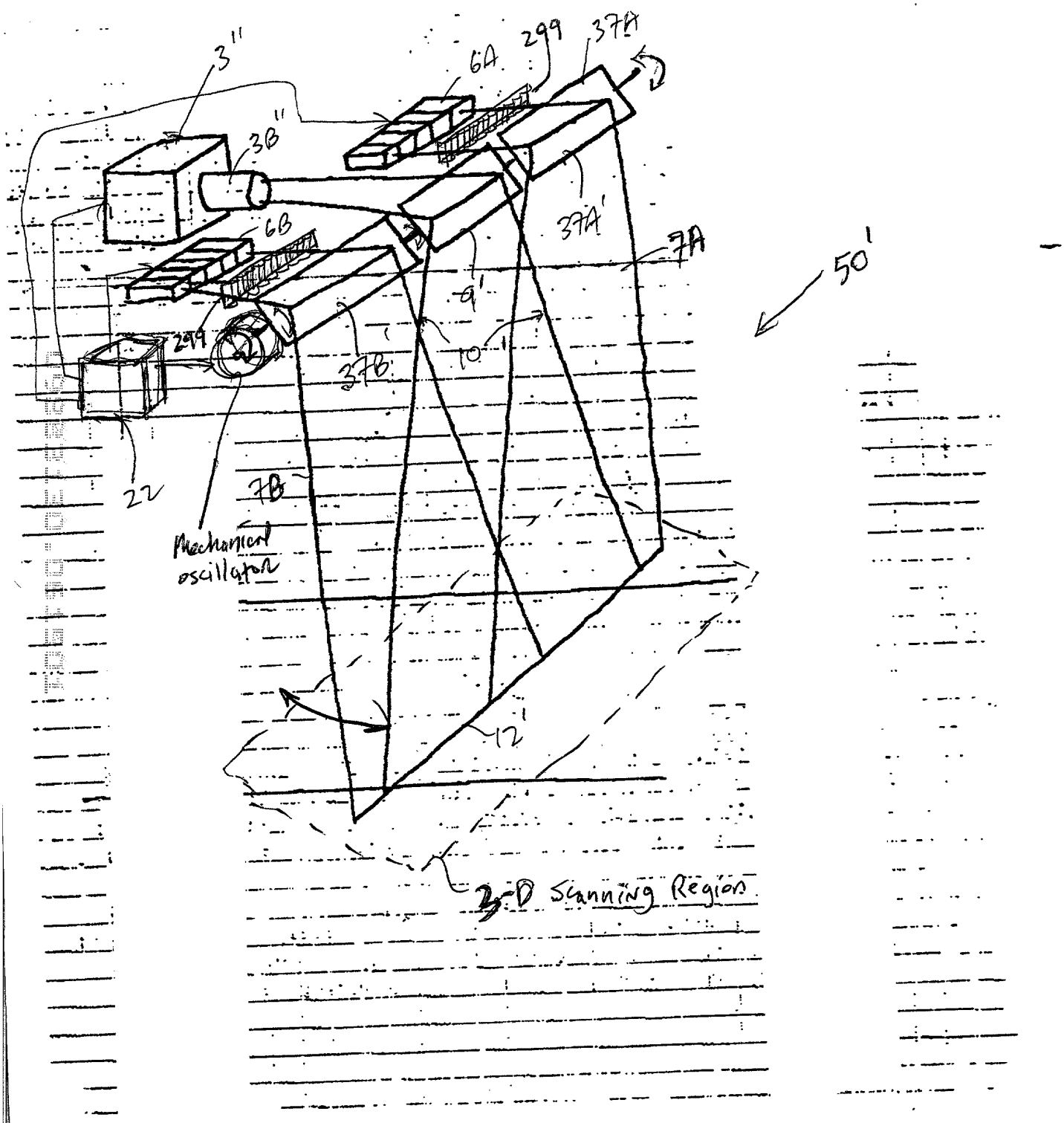
3''
6A
299
37A
3B''
37A'
6B
7A
50'
9'
299
10'
37B
22
7B
Mechanical oscillator
12'
3-D Scanning Region

FIG. 3J2

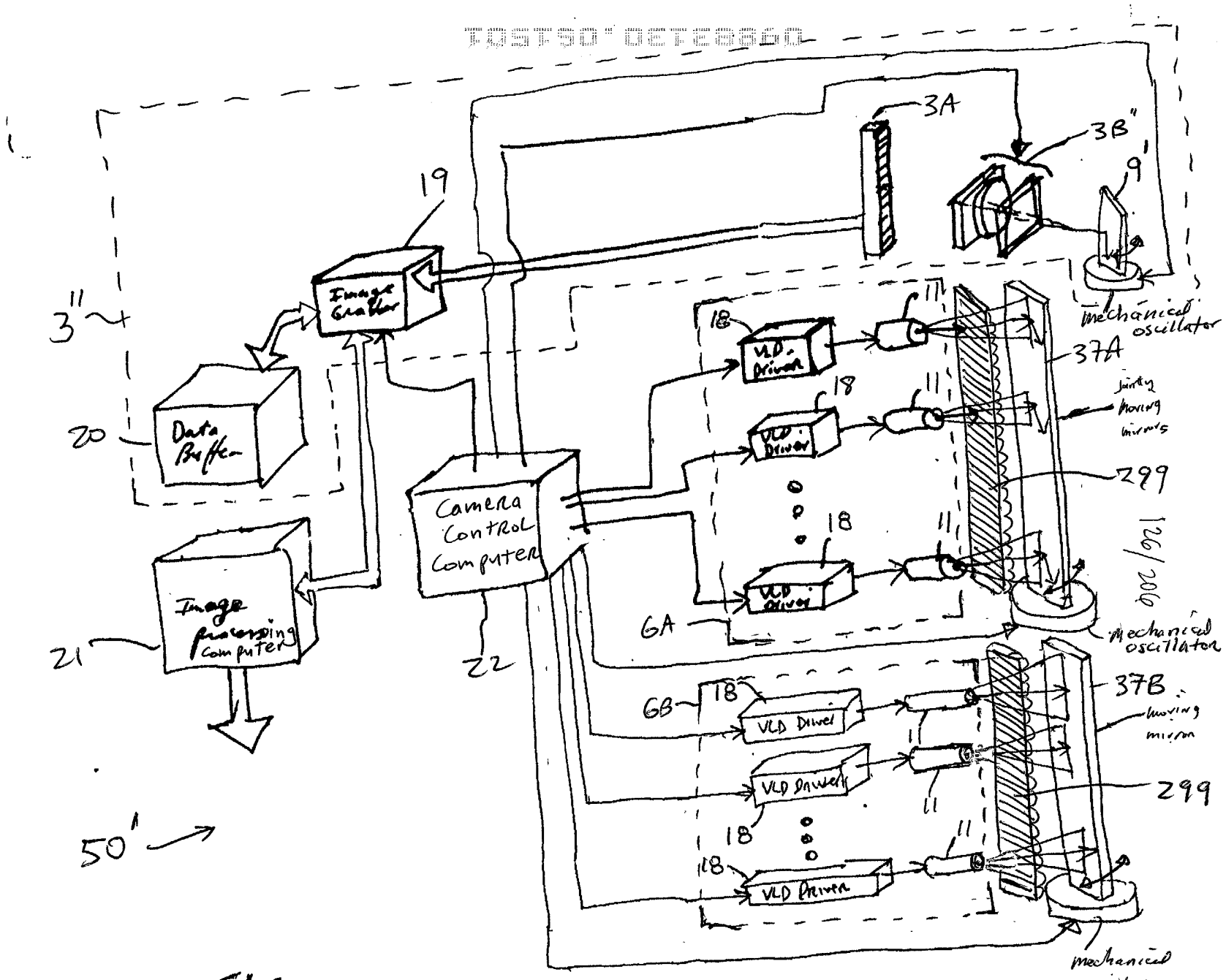
3A
3B"
9'
19
3"
Image Grabber
Data Buffer
20
Camera Control Computer
Image processing Computer
21
22
50'
18
VLD Driver
37A
Moving mirrors
299
126/206
GA
mechanical oscillator
GB
37B
Moving mirror
mechanical oscillator

FIG. 3J3

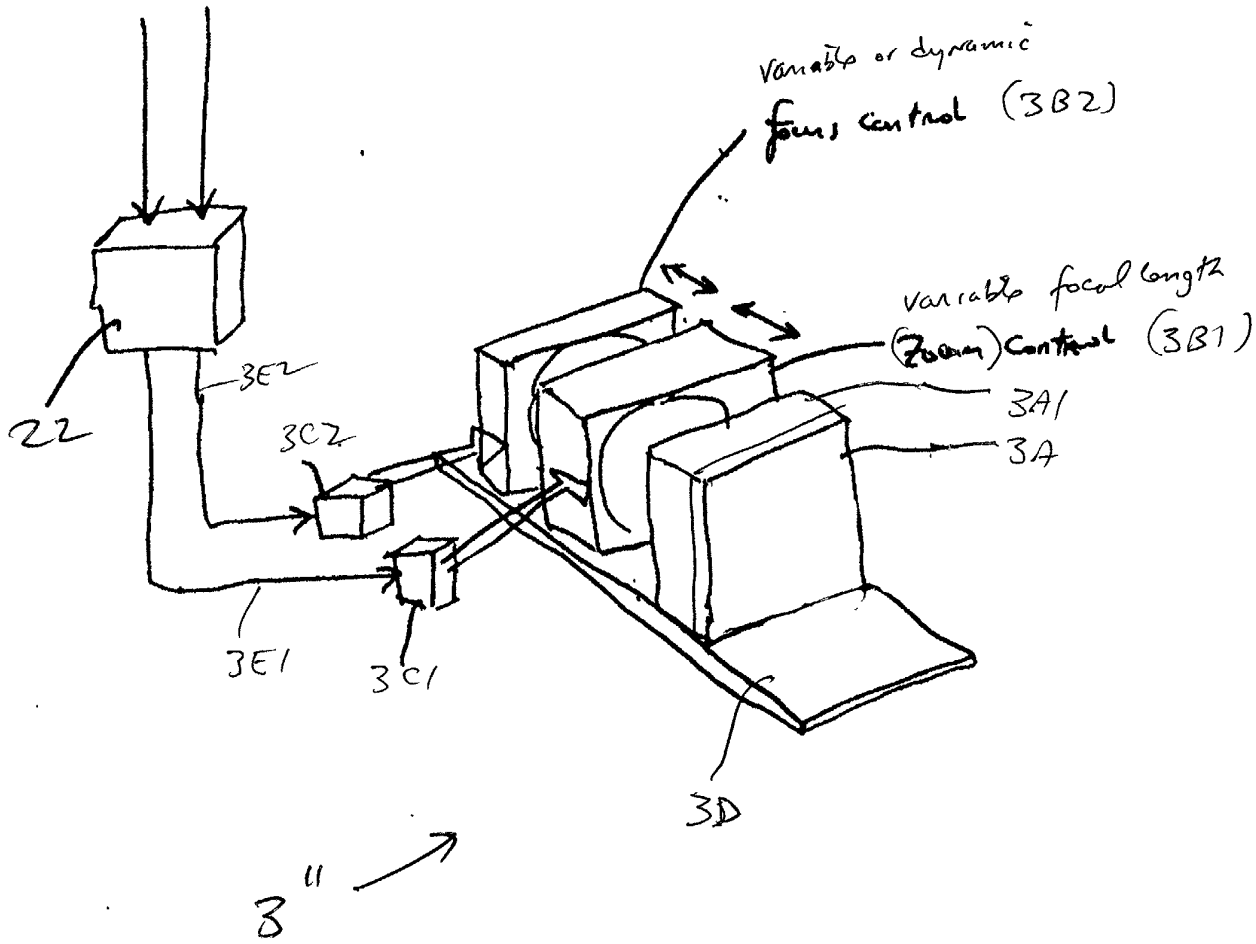
variable or dynamic
focus control (3B2)
variable focal length
(Zoom) Control (3B1)
3A1
3A
3E2
3C2
22
3E1
3C1
3D
3"

FIG. 3J4

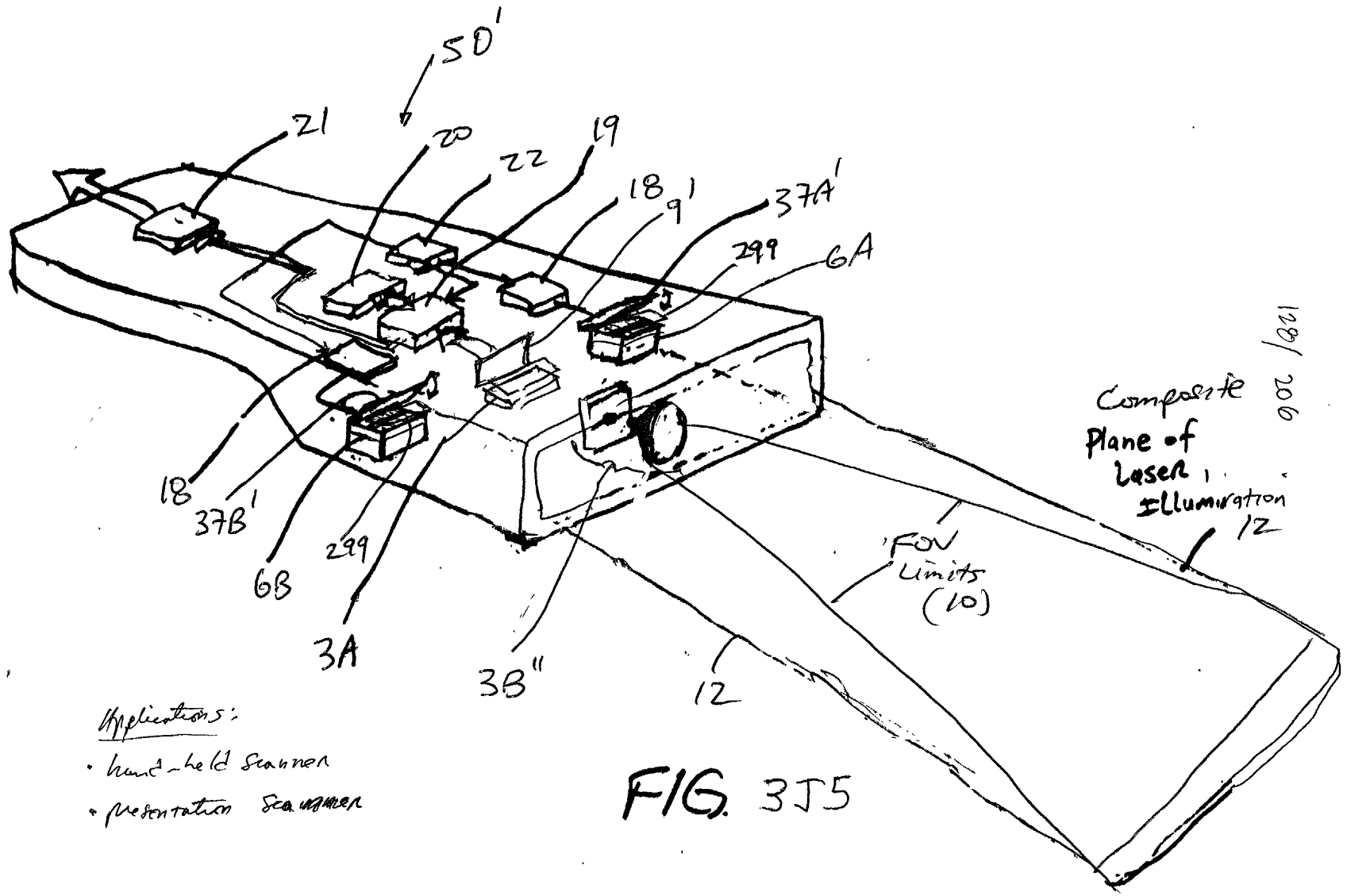
50'
21
20
22
19
18
9'
37A'
299
6A
18
37B'
6B
299
3A
3B"
12
Composite
Plane of
Laser
Illumination
12
FOV
Limits
(10)
206
Applications:
• hand-held scanner
• presentation scanner

FIG. 3J5

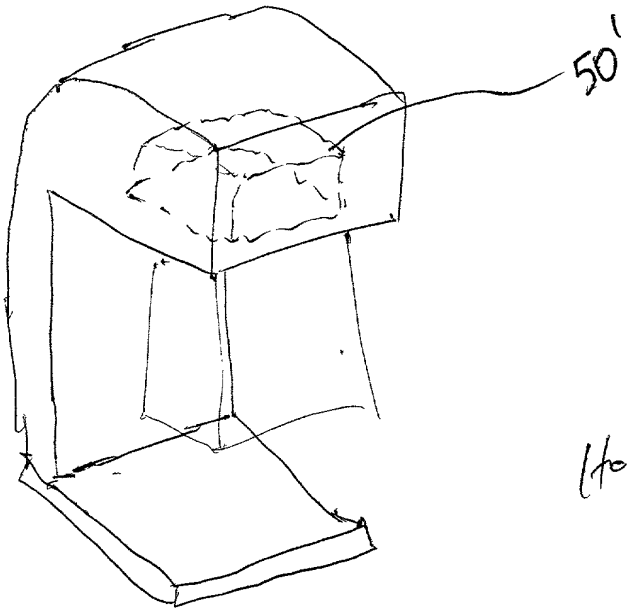

FIG-3J6

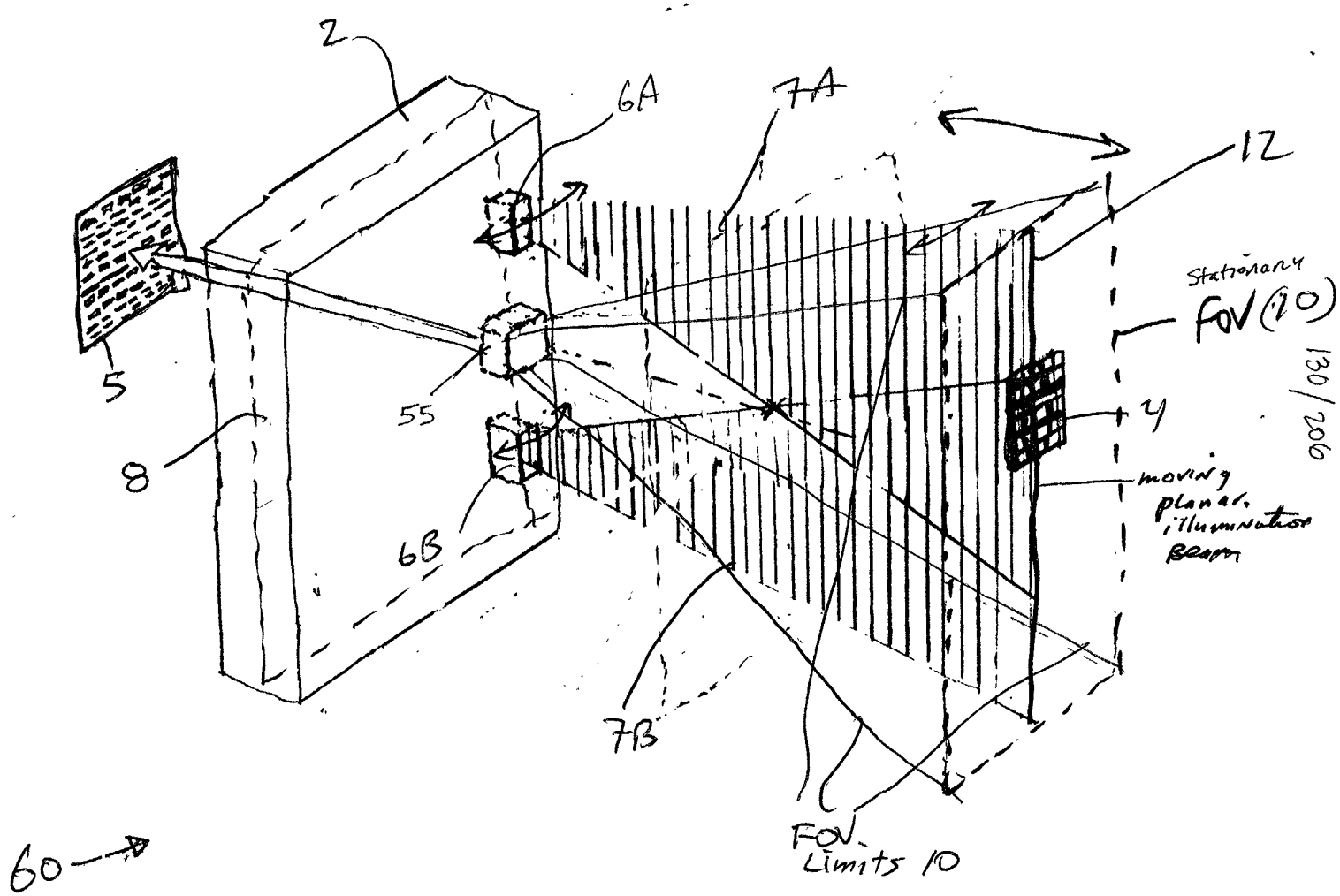

FIG 4A

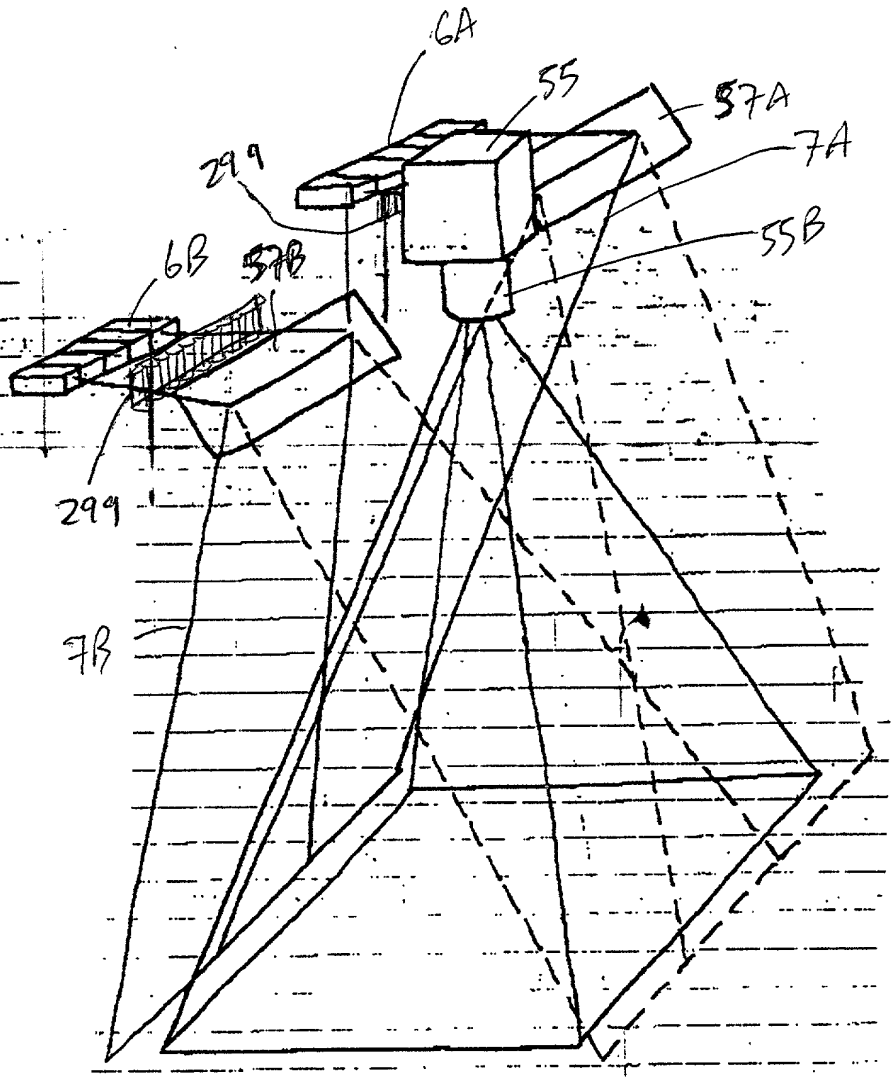

FIG. 4B1

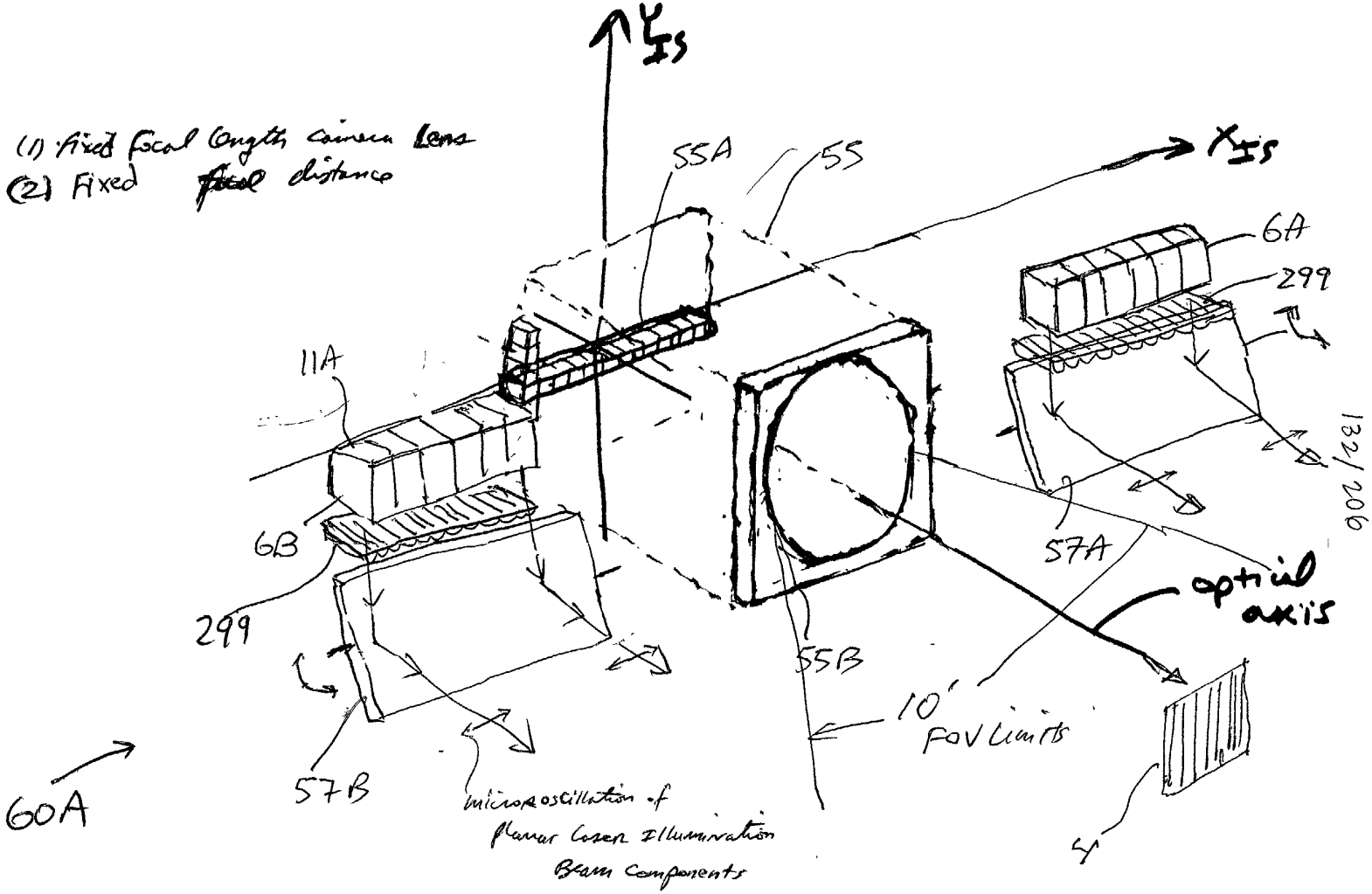

FIG. 4B 2

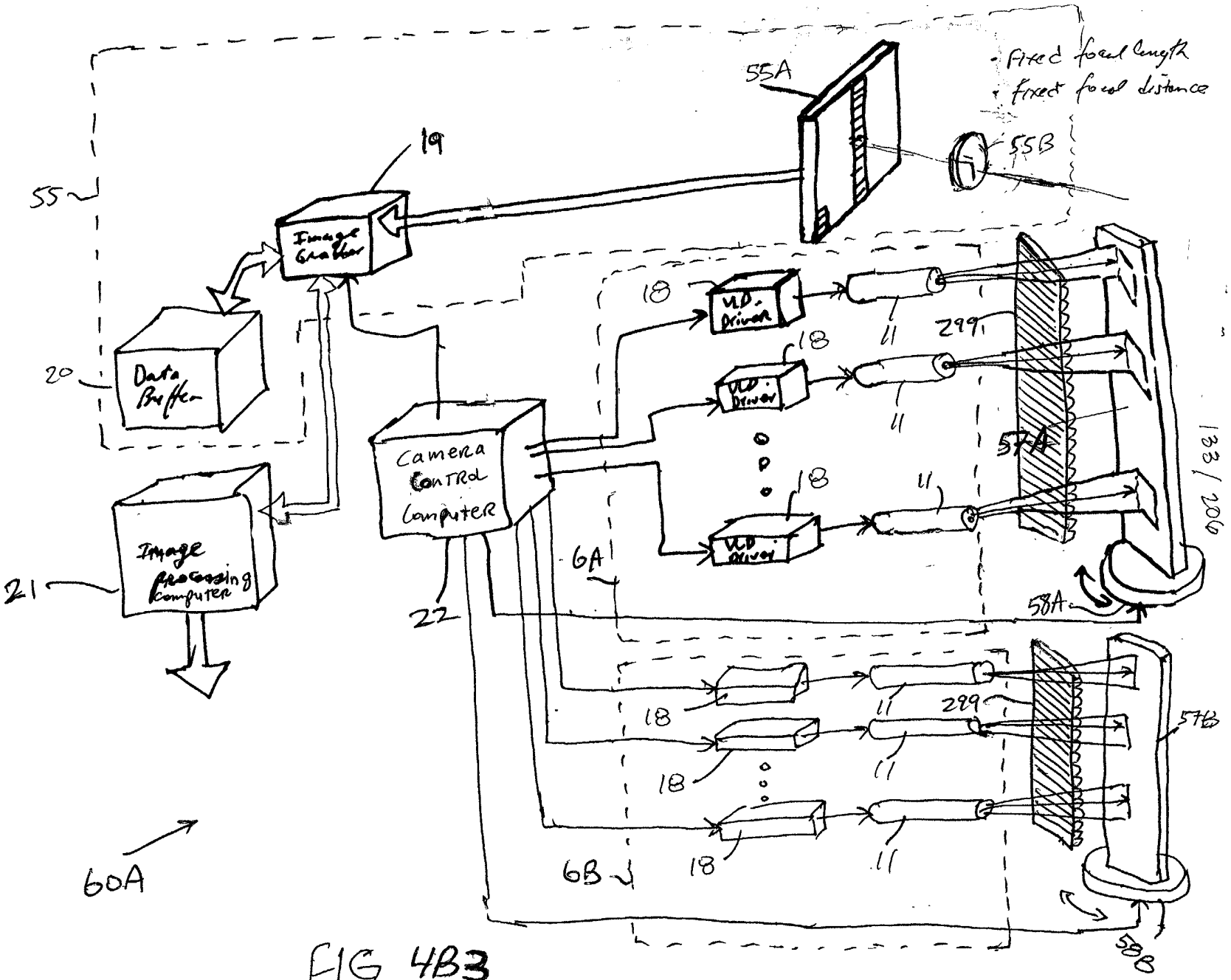

FIG. 4B3

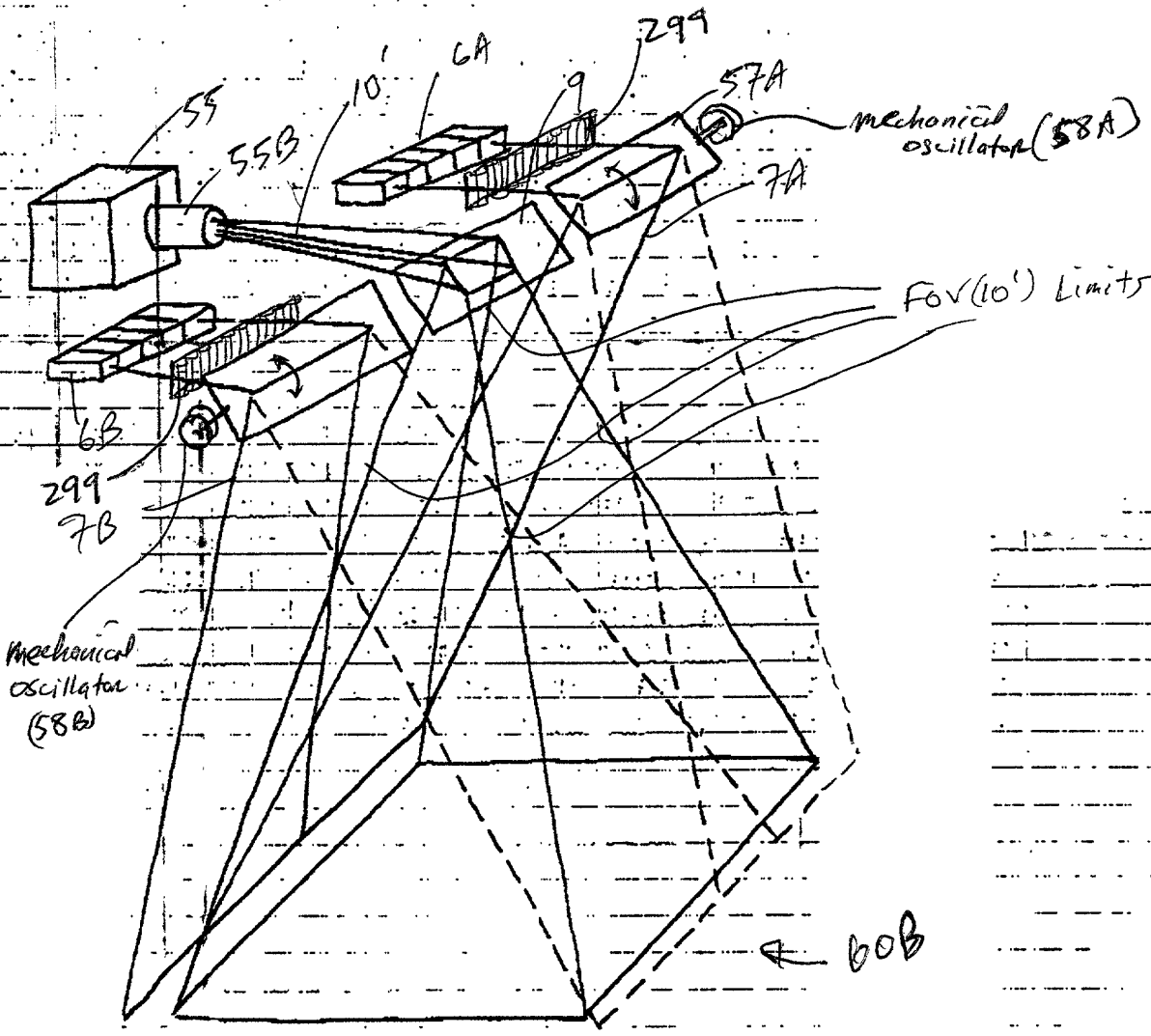
55
55B
10'
6A
9
299
57A
mechanical oscillator (58A)
7A
FoV(10') Limits
6B
299
7B
mechanical oscillator (58B)
60B

FIG. 4C1

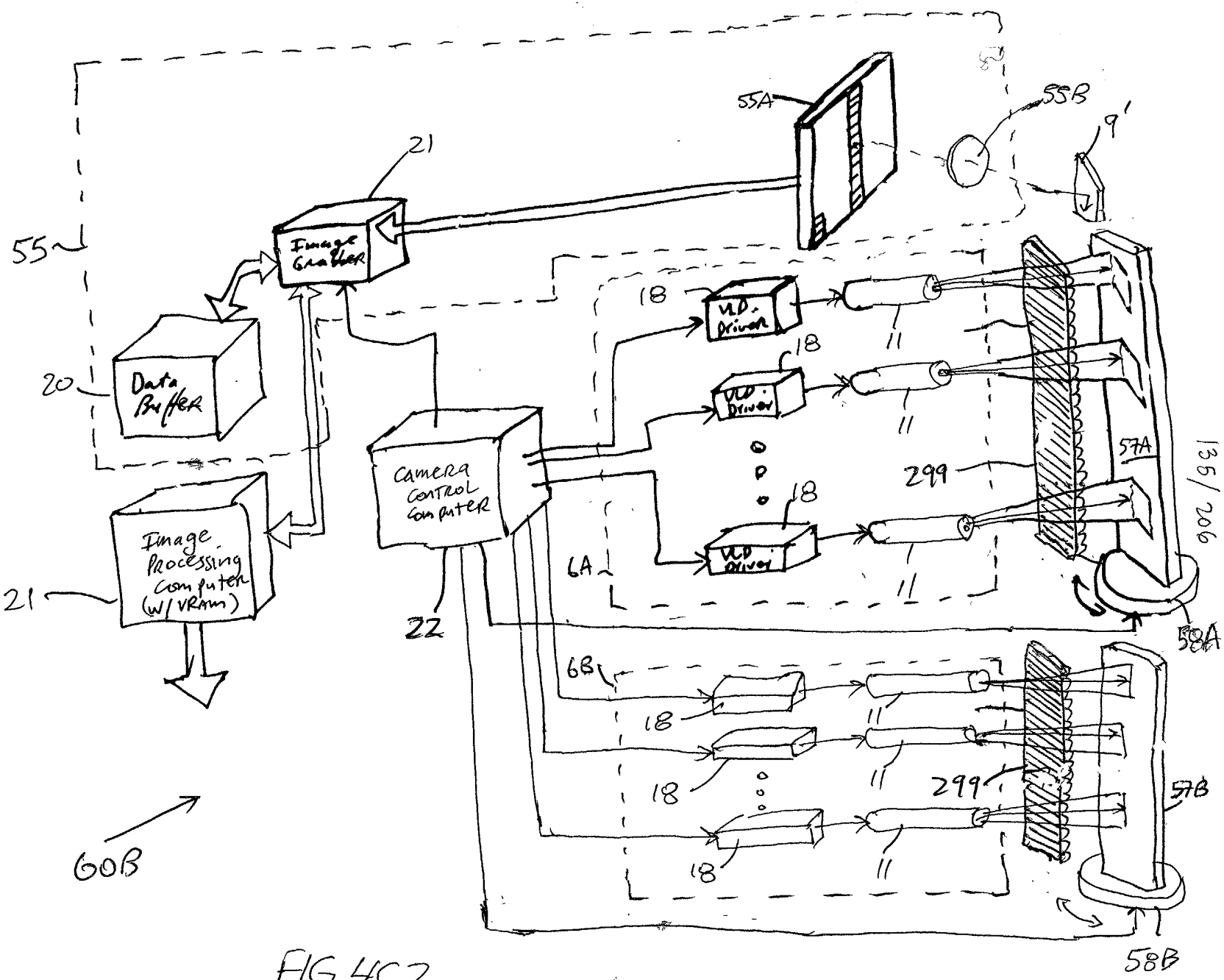

FIG. 4C2

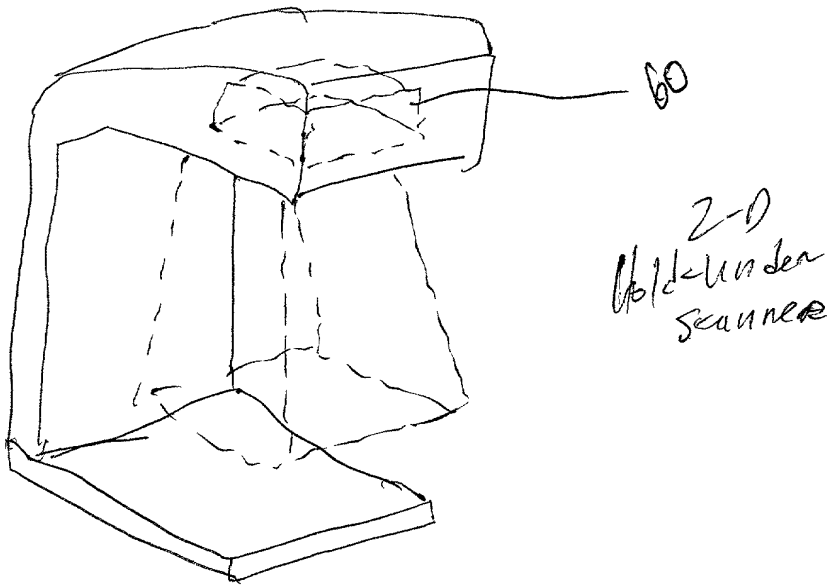

FIG. 4D

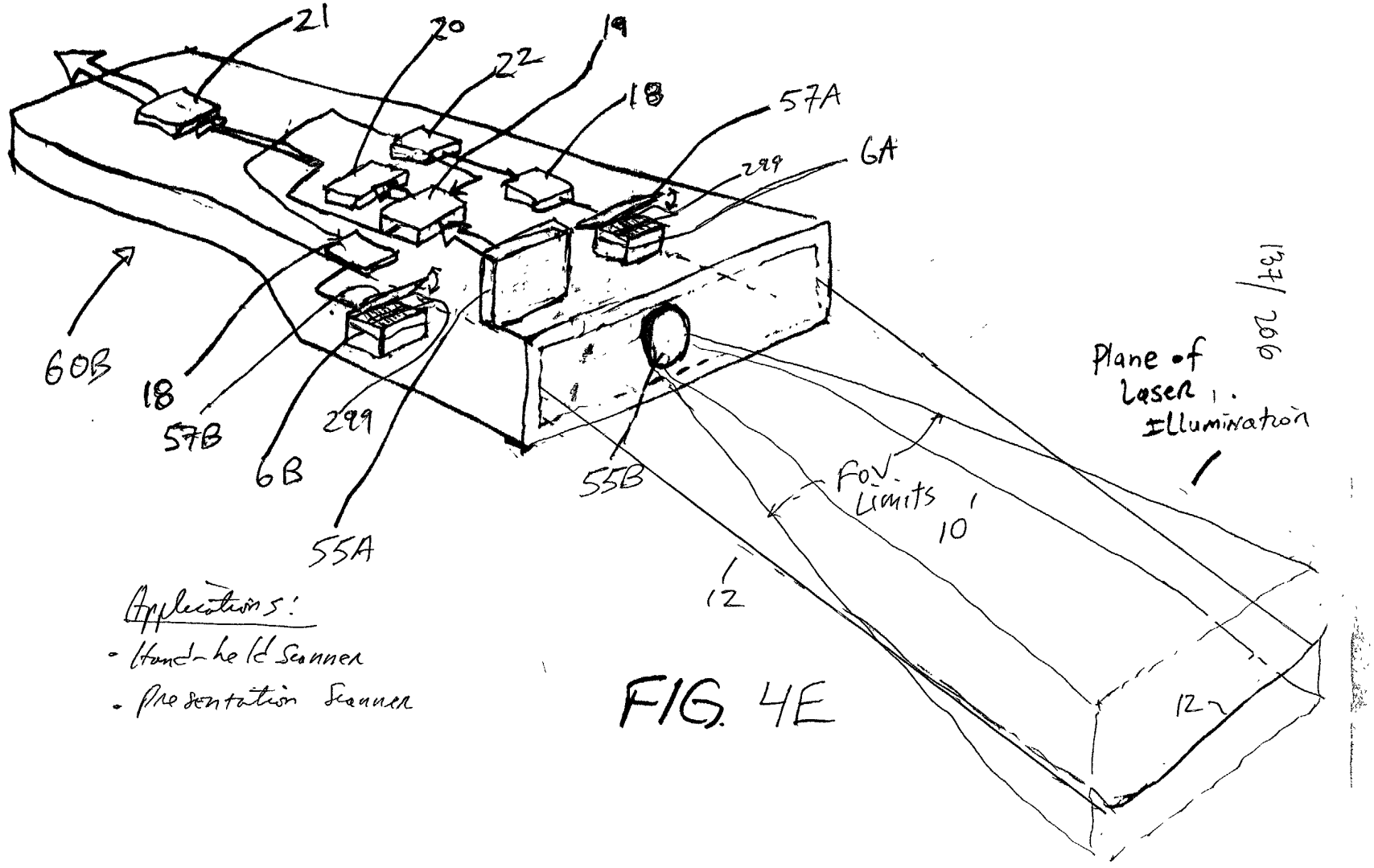
21
20
22
19
18
57A
299
6A
60B
18
57B
299
6B
55A
55B
Plane of Laser Illumination
FOV Limits
10
12
12
Applications:
- Hand-held Scanner
- Presentation Scanner

FIG. 4E

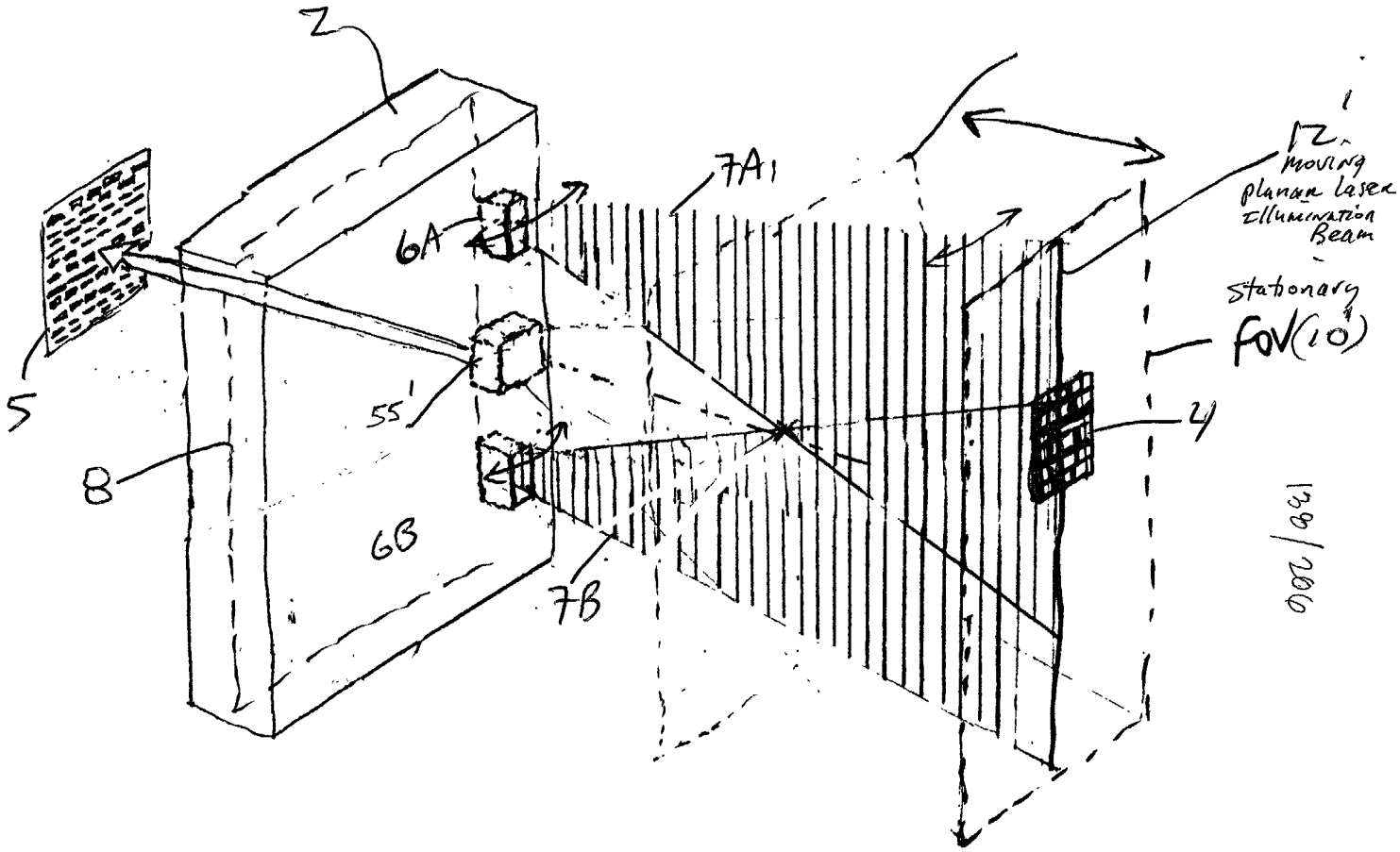
2
7A
6A
5
55'
8
6B
7B
4
Moving planar laser illumination Beam
Stationary FOV(10)
70

FIG 5A

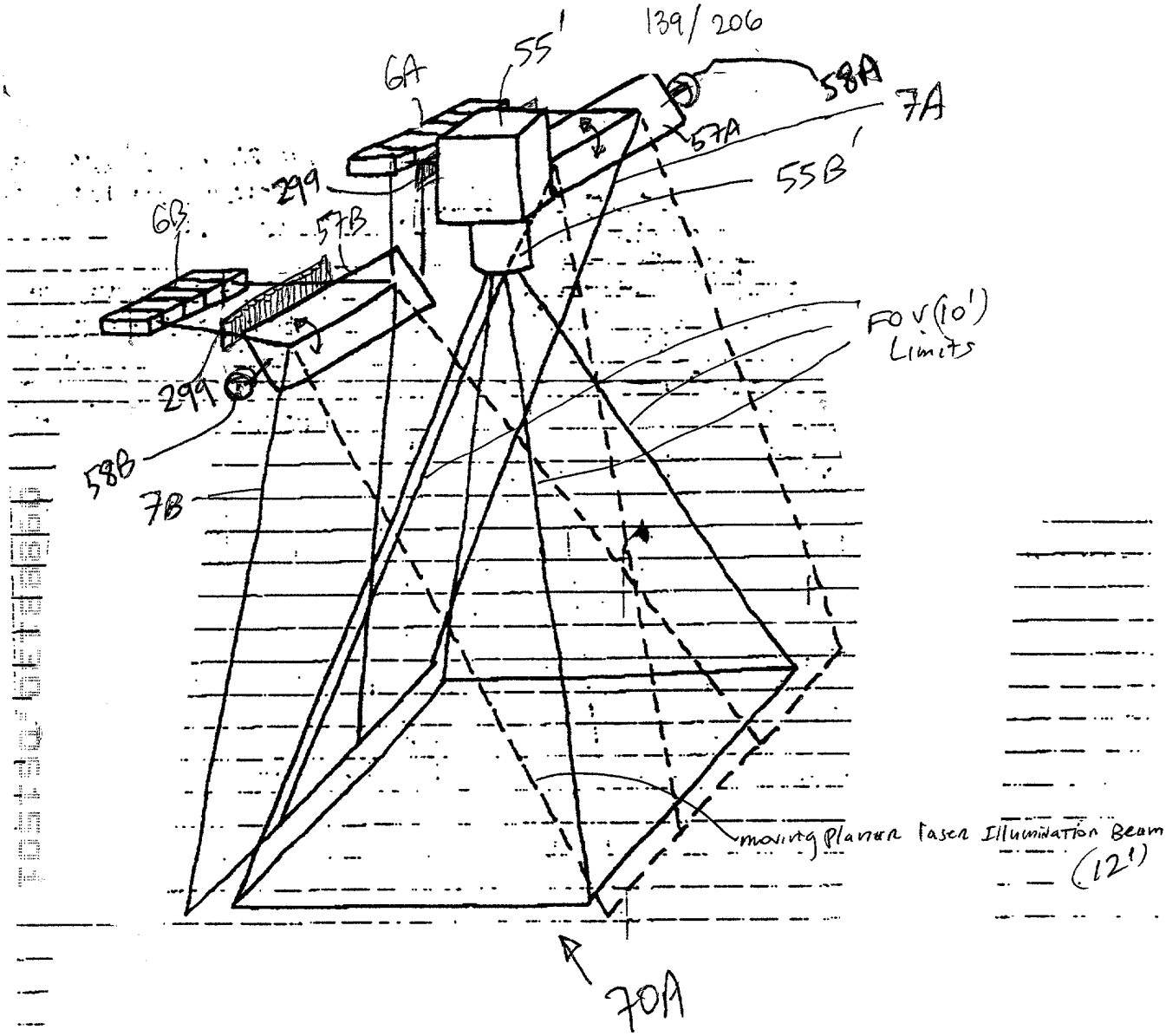
139/206
55'
6A
58A
7A
57A
55B'
299
6B
57B
FOV (10')
Limits
299
58B
7B
moving Planar Laser Illumination Beam
(12')
70A

FIG. 5B1

(1) Fixed focal length camera lens
(2) Variable focal distance

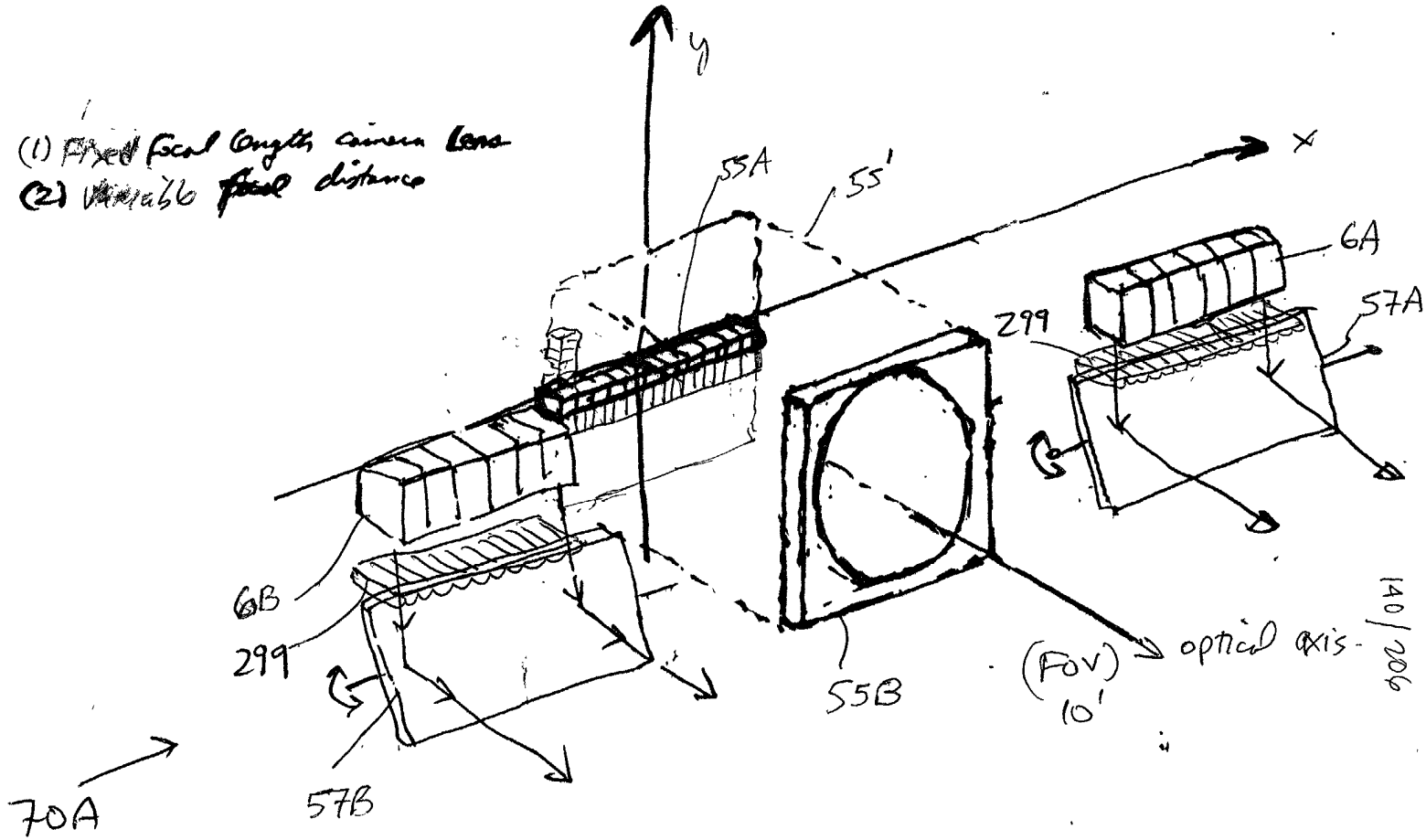

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FIG. 5B2

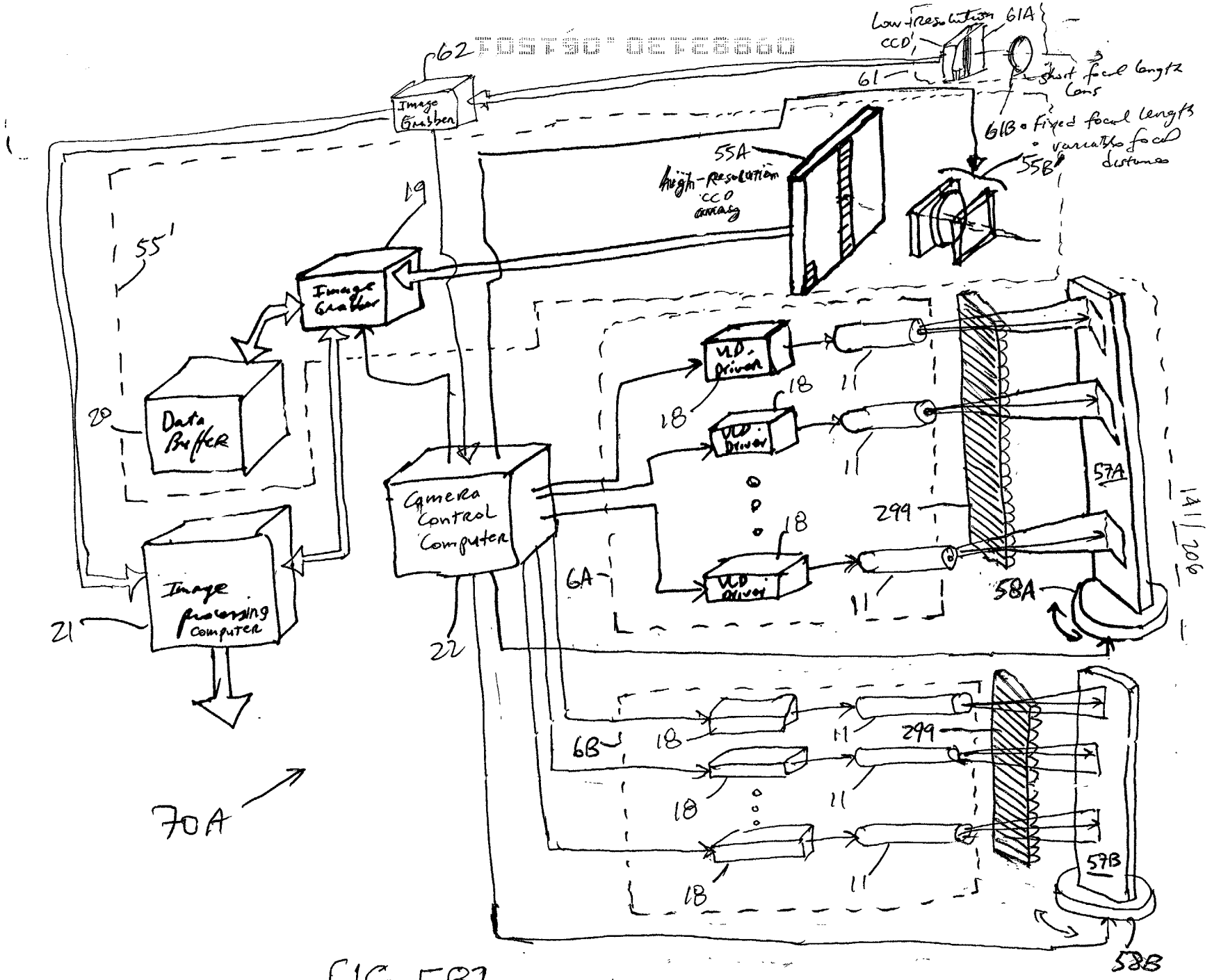

Low-resolution CCD
61A
62
61
Image Grabber
Short focal length Lens
61B • Fixed focal length • variable focal distance
55A
High-Resolution CCD array
55B
19
55'
Image Grabber
VLD Driver
18
11
20
Data Buffer
Camera Control Computer
299
57A
141
206
6A
58A
Image processing Computer
21
22
6B
57B
58B
70A

FIG. 5B3

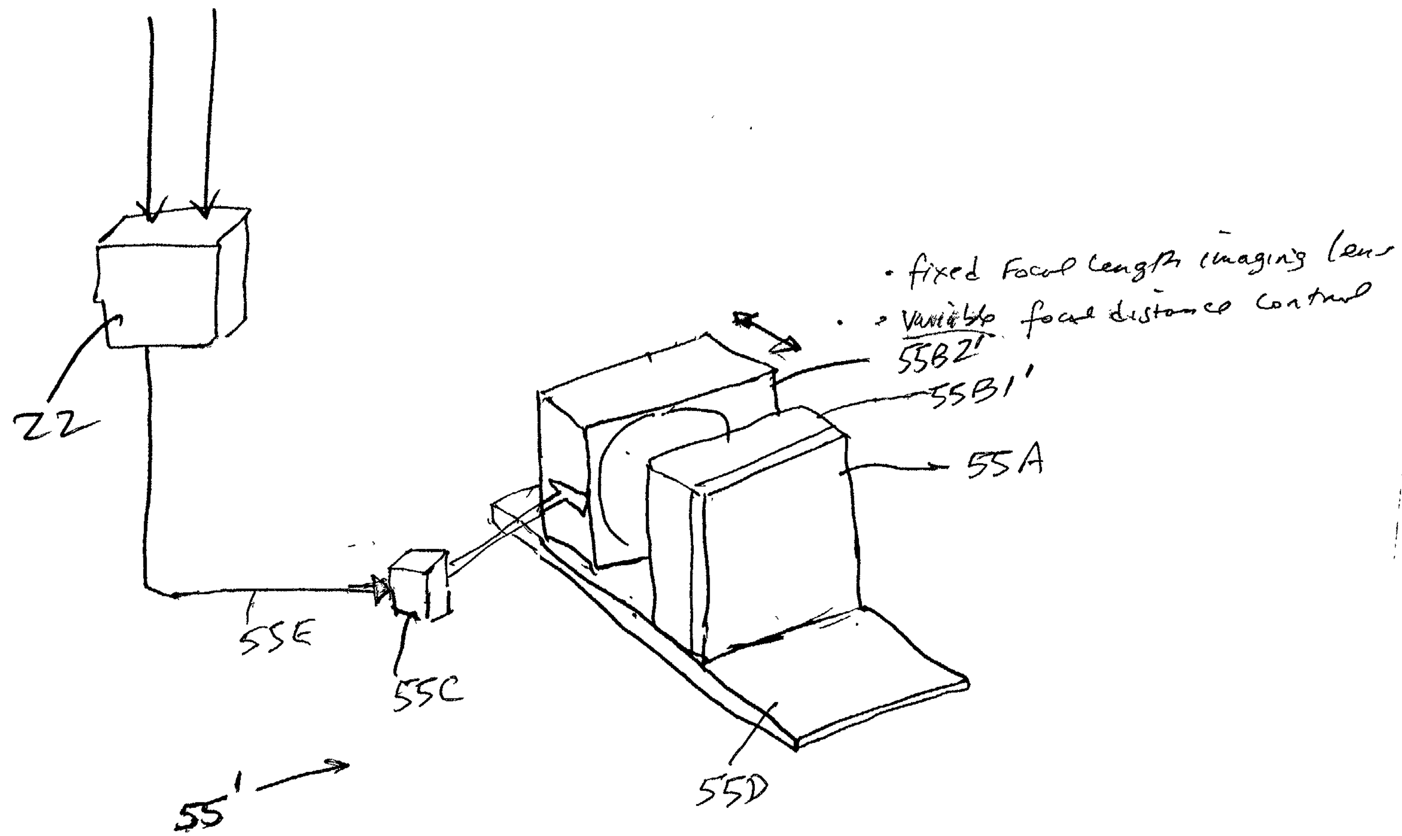

• fixed focal length imaging lens
• variable focal distance control
55B2'
55B1'
55A
55D
55C
55E
22
55'

FIG. 5B4

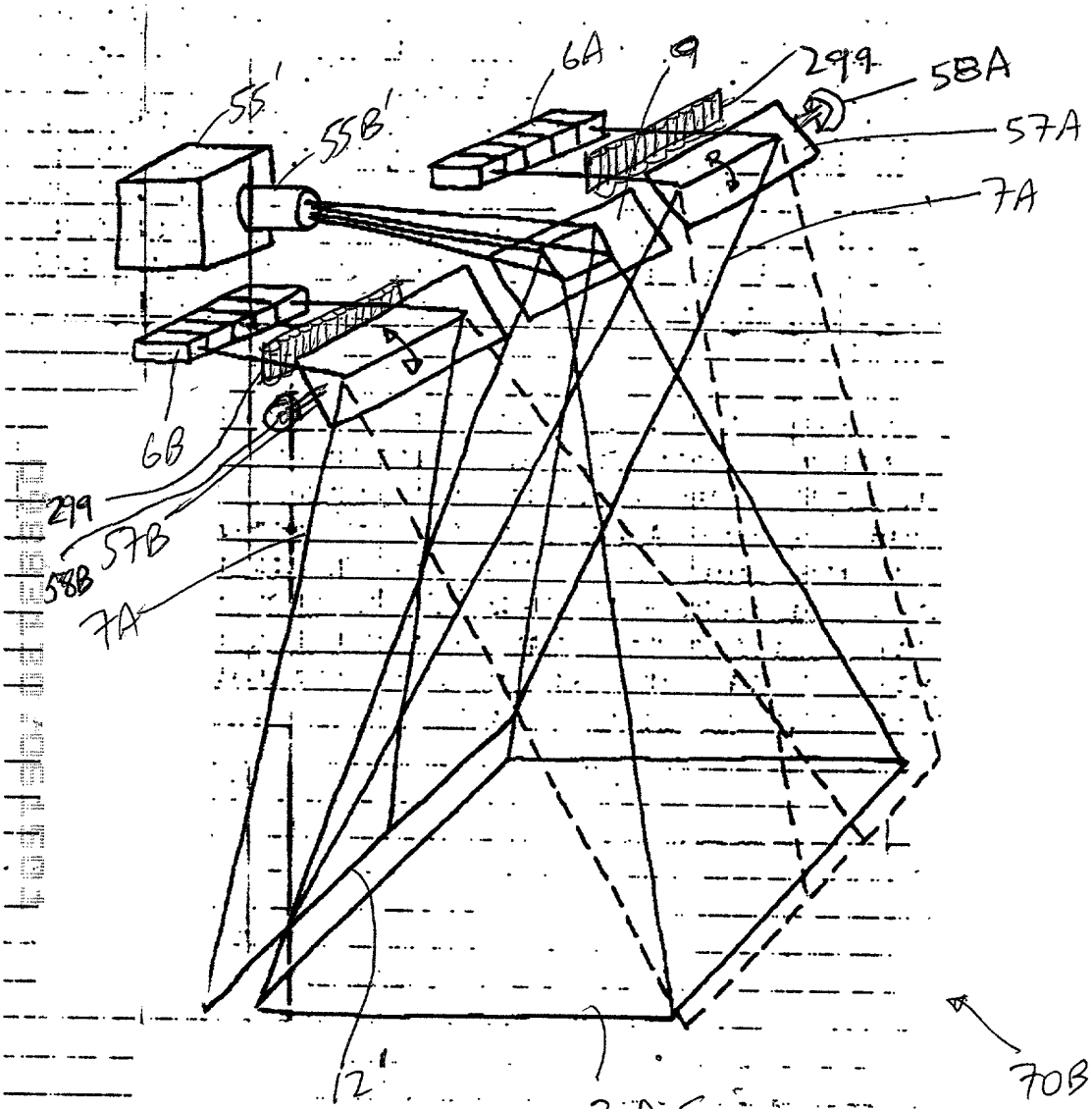

55'
55B'
6A
9
299
58A
57A
7A
6B
299
57B
58B
7A
12'
3-D Scanning Region
70B

FIG. 5C1

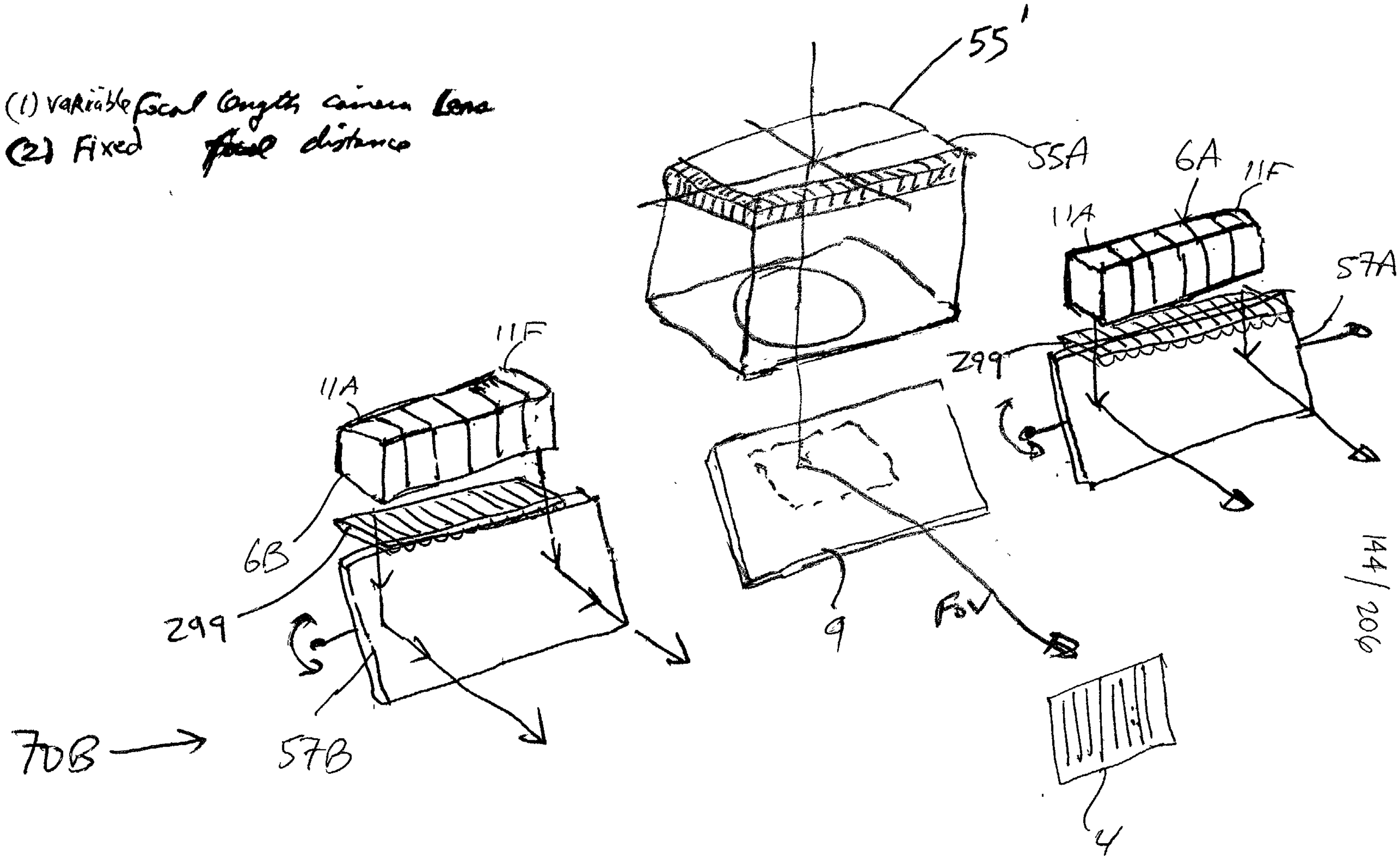

(1) variable focal length camera lens
(2) Fixed focal distance
55'
55A
6A
11F
11A
57A
299
11F
11A
6B
299
9
FOV
4
70B
57B

FIG. 5C2

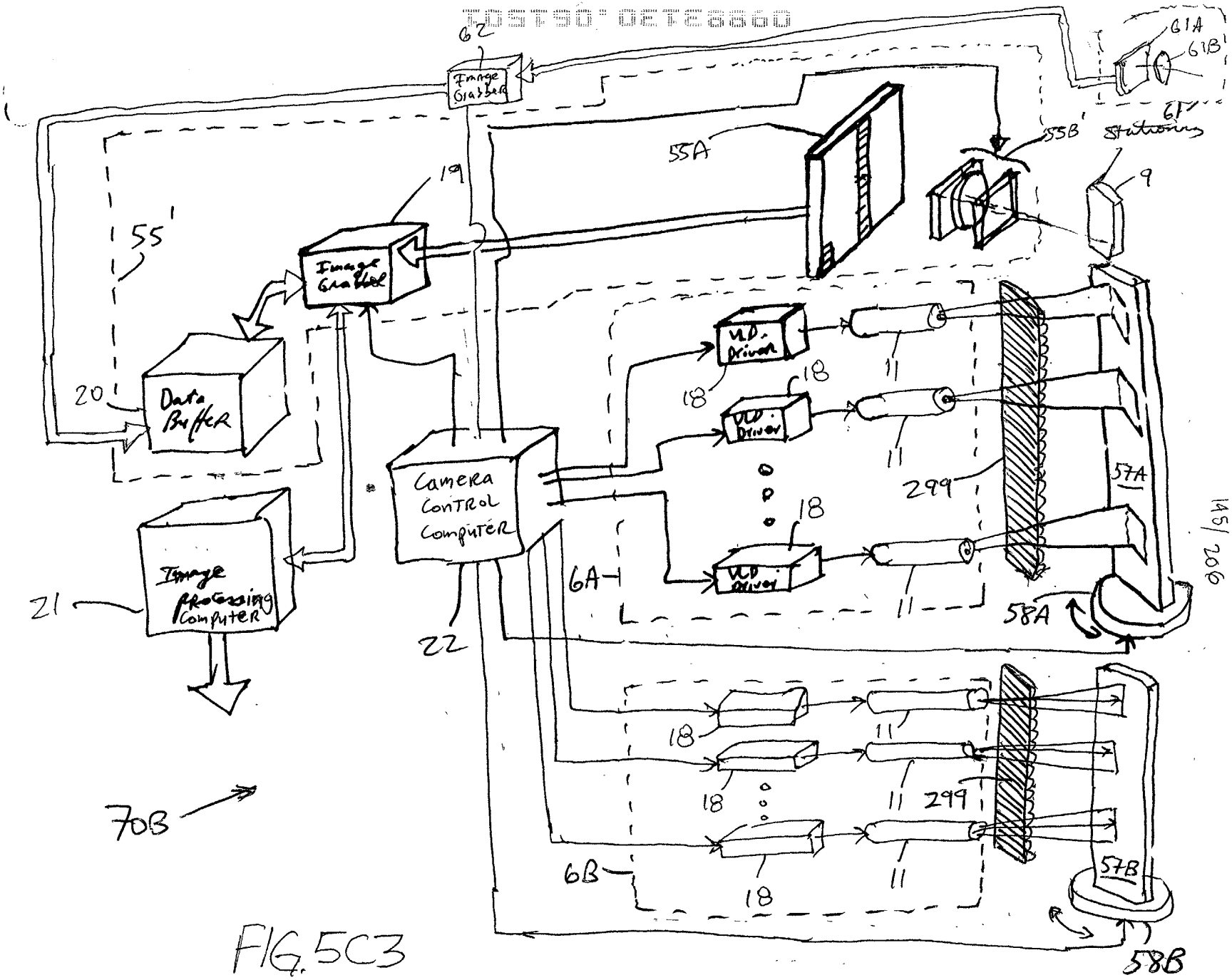

62
Image Grabber
61A
61B
61
Stations
55A
55B
9
19
55
Image Grabber
20
Data Buffer
LCD driver
18
11
299
57A
Camera Control Computer
6A
58A
21
Image Processing Computer
22
6B
57B
58B
70B

FIG. 5C3

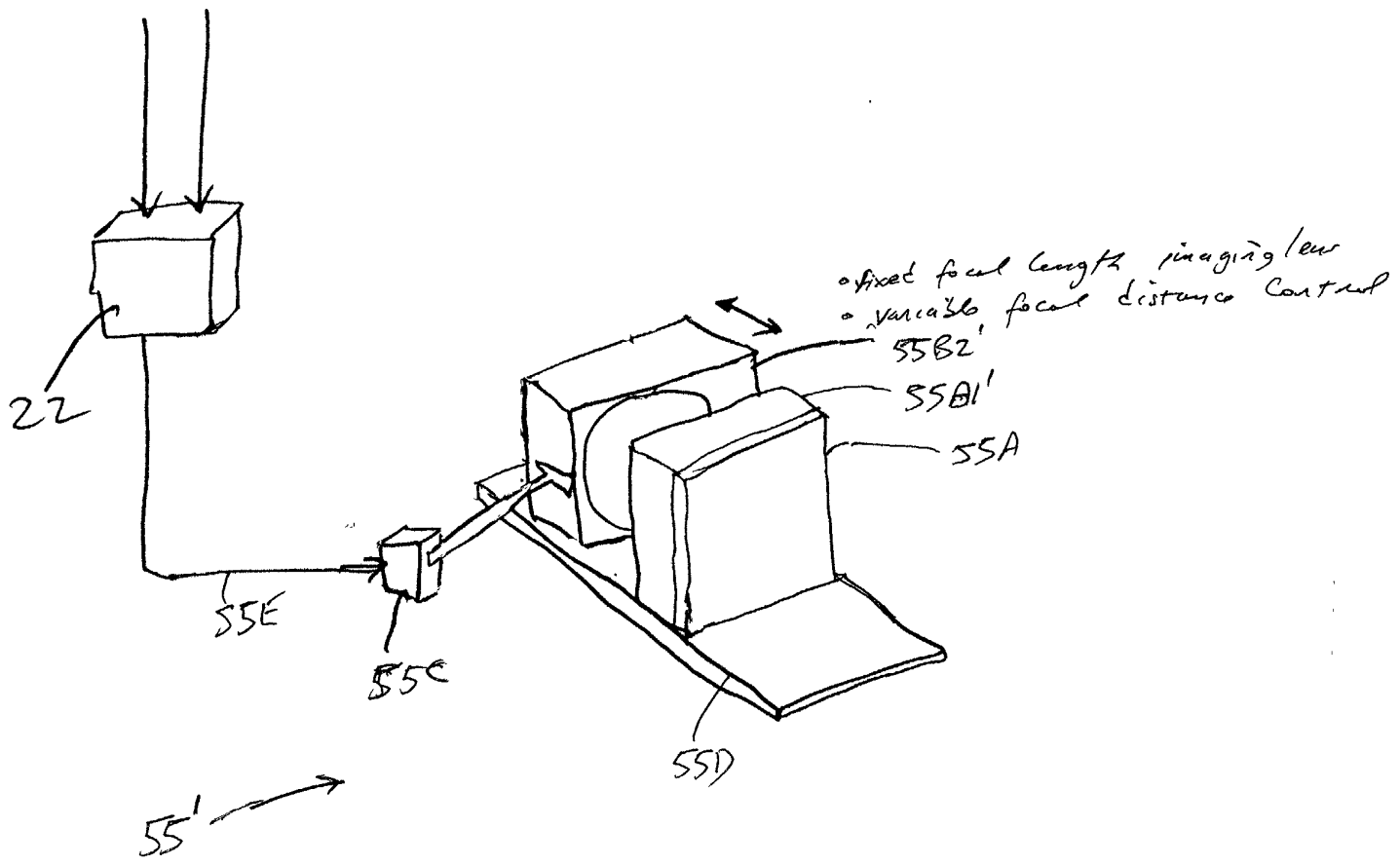

22
55E
55C
55'
55D
55A
55B1'
55B2'
• fixed focal length imaging lens
• variable focal distance control

FIG. 5C4

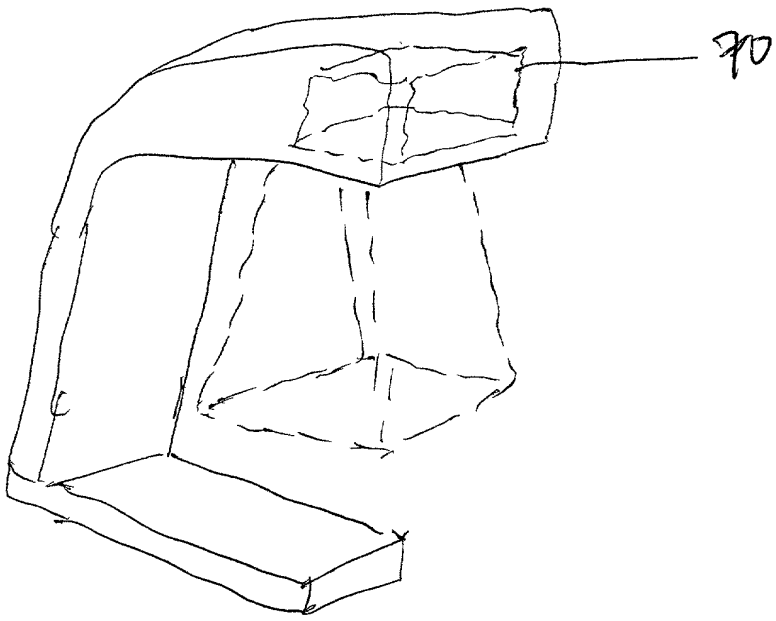


FIG. 5D

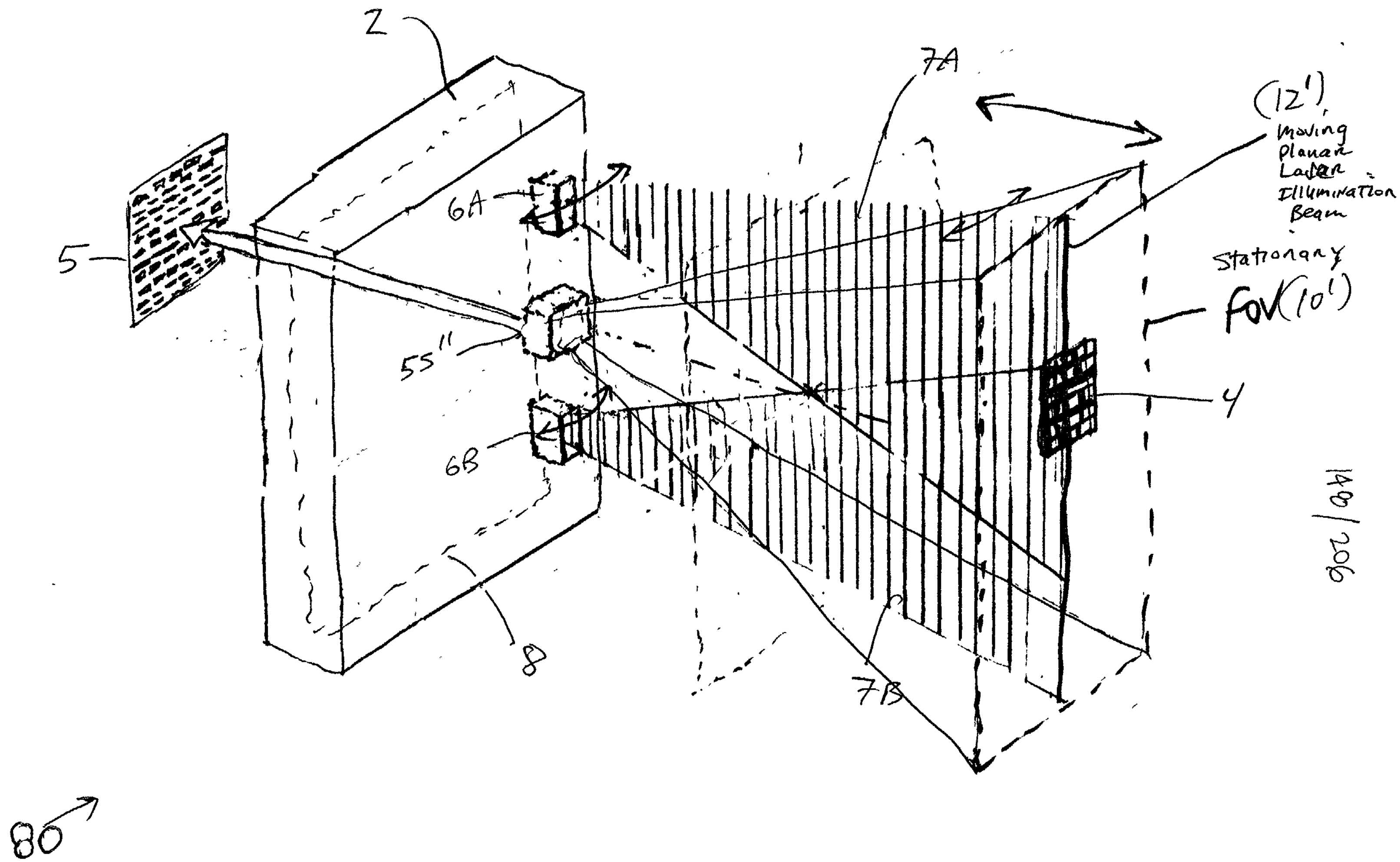

2
5
6A
55''
6B
8
7A
7B
(12'), Moving Planar Laser Illumination Beam
Stationary FOV (10')
4
80

FIG. 6A

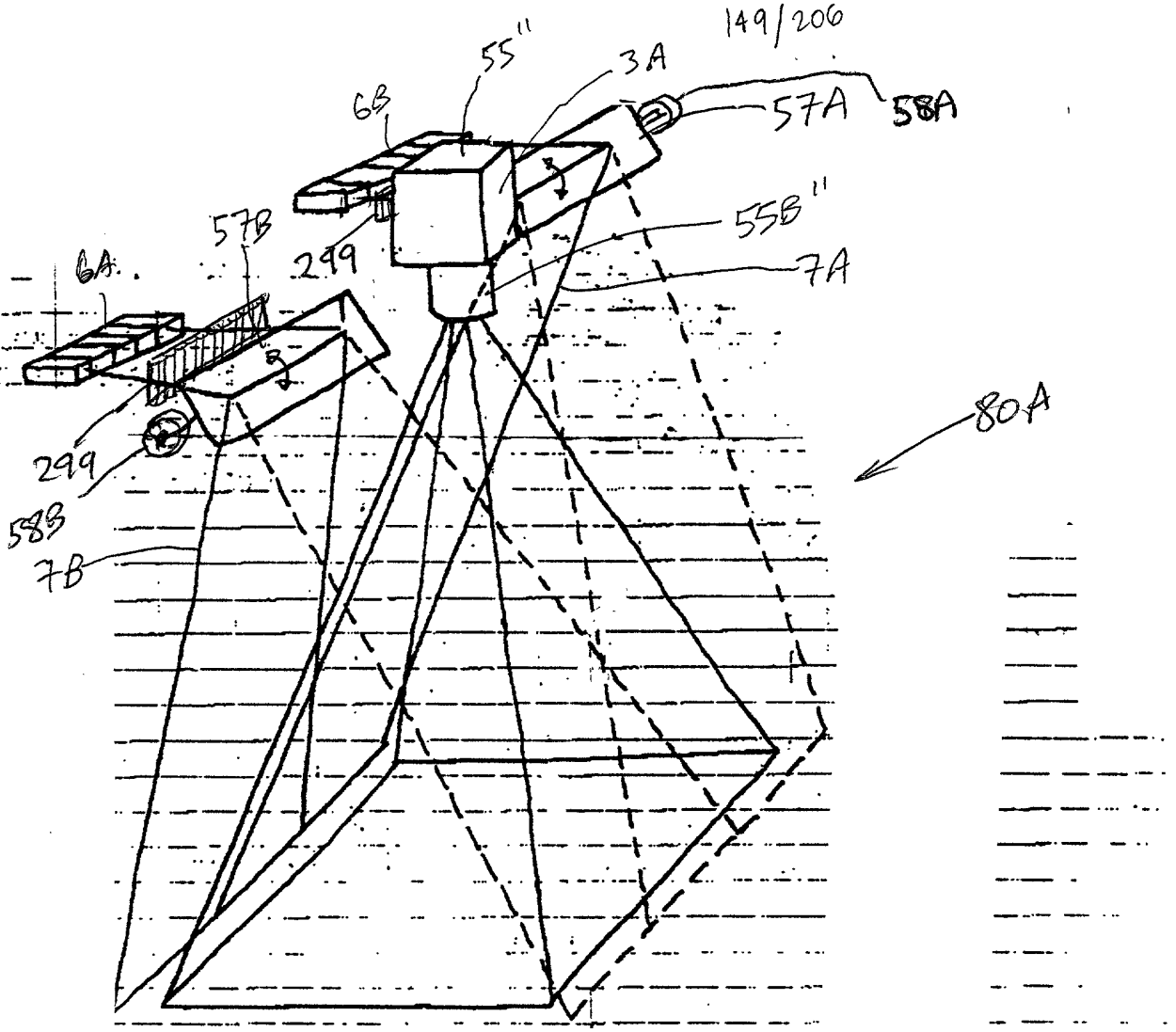


FIG. 6B1

(1) Variable focal length camera lens
(2) variable ~~focal~~ distance

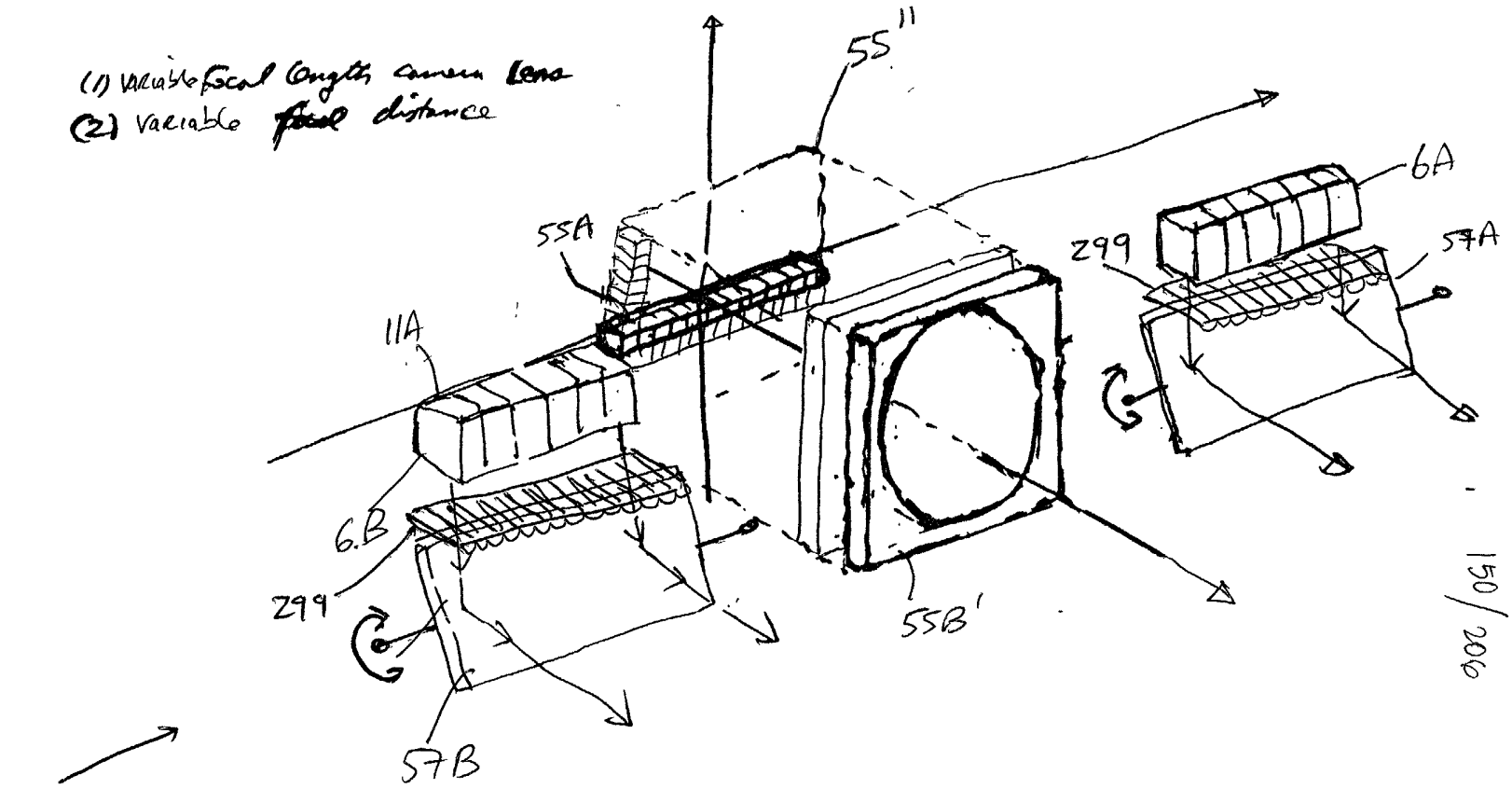


FIG. 6B2

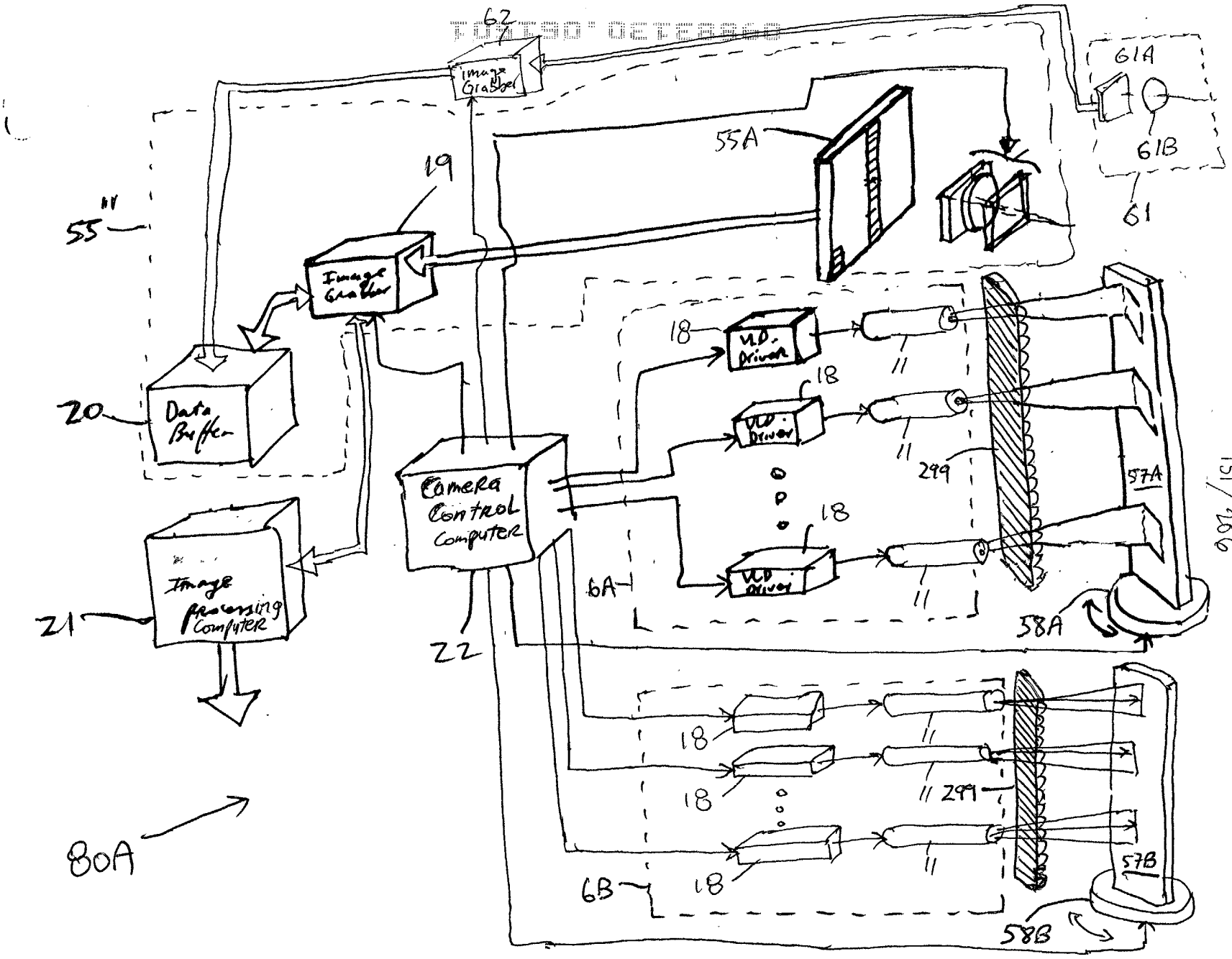

62
Image Grabber
61A
61B
61
55A
19
55"
Image Grabber
18
VLD Driver
18
VLD Driver
299
57A
20
Data Buffer
Camera Control Computer
18
VLD Driver
6A
58A
21
Image Processing Computer
22
18
18
299
18
57B
6B
58B
80A

FIG. 6B3

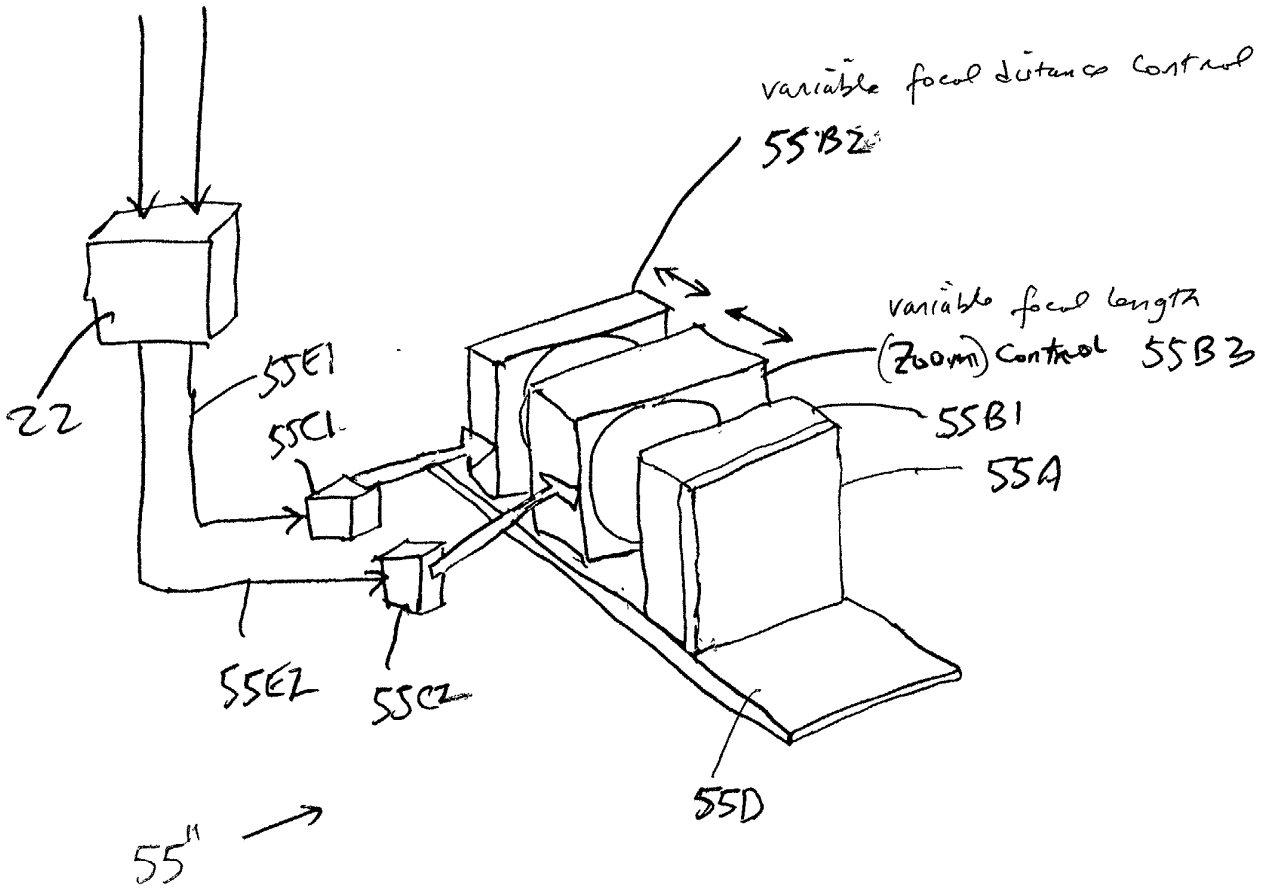


FIG. 6B4

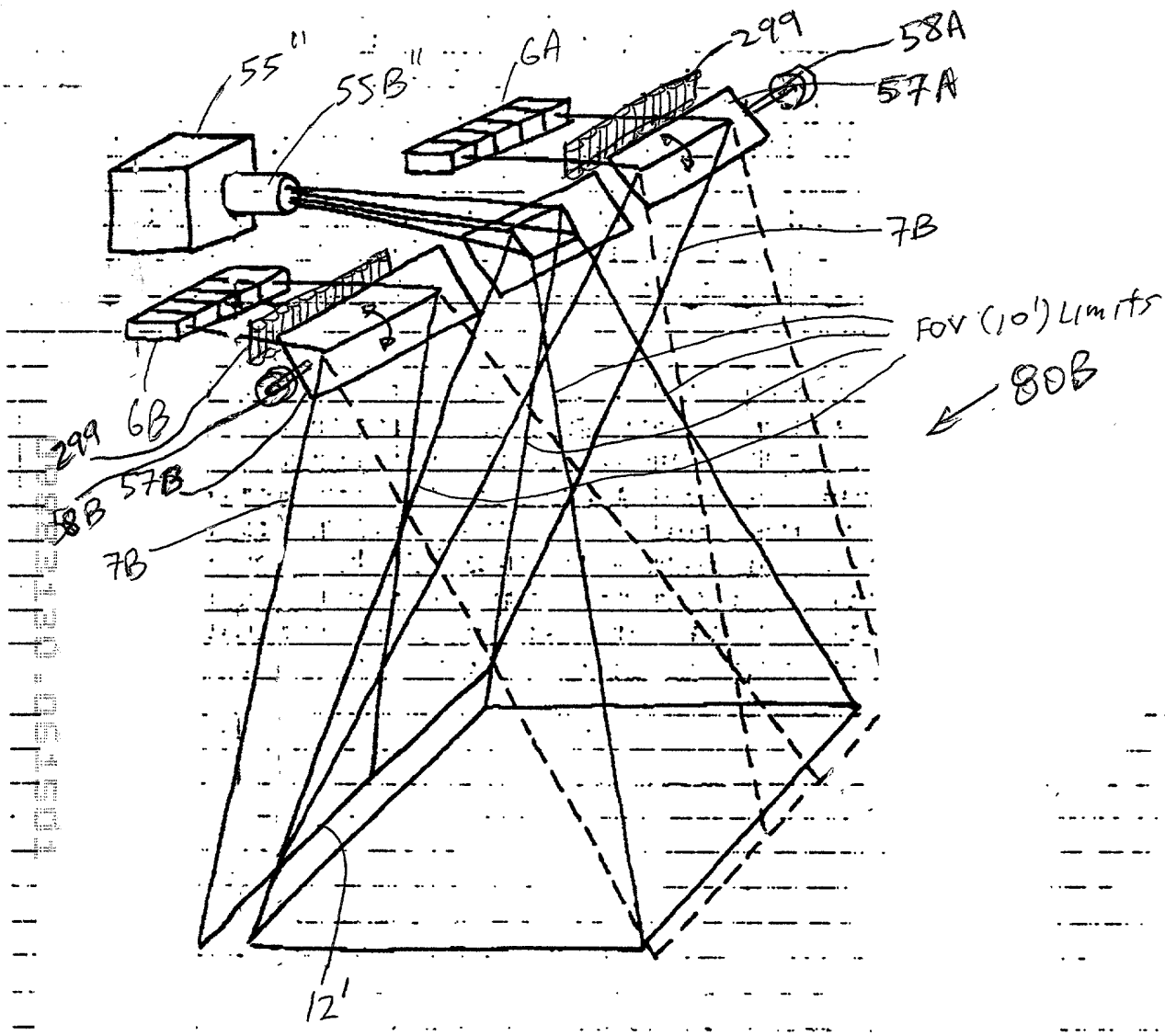


FIG. 6C1

(1) Variable focal length camera lens
(2) Variable ~~focal~~ distance

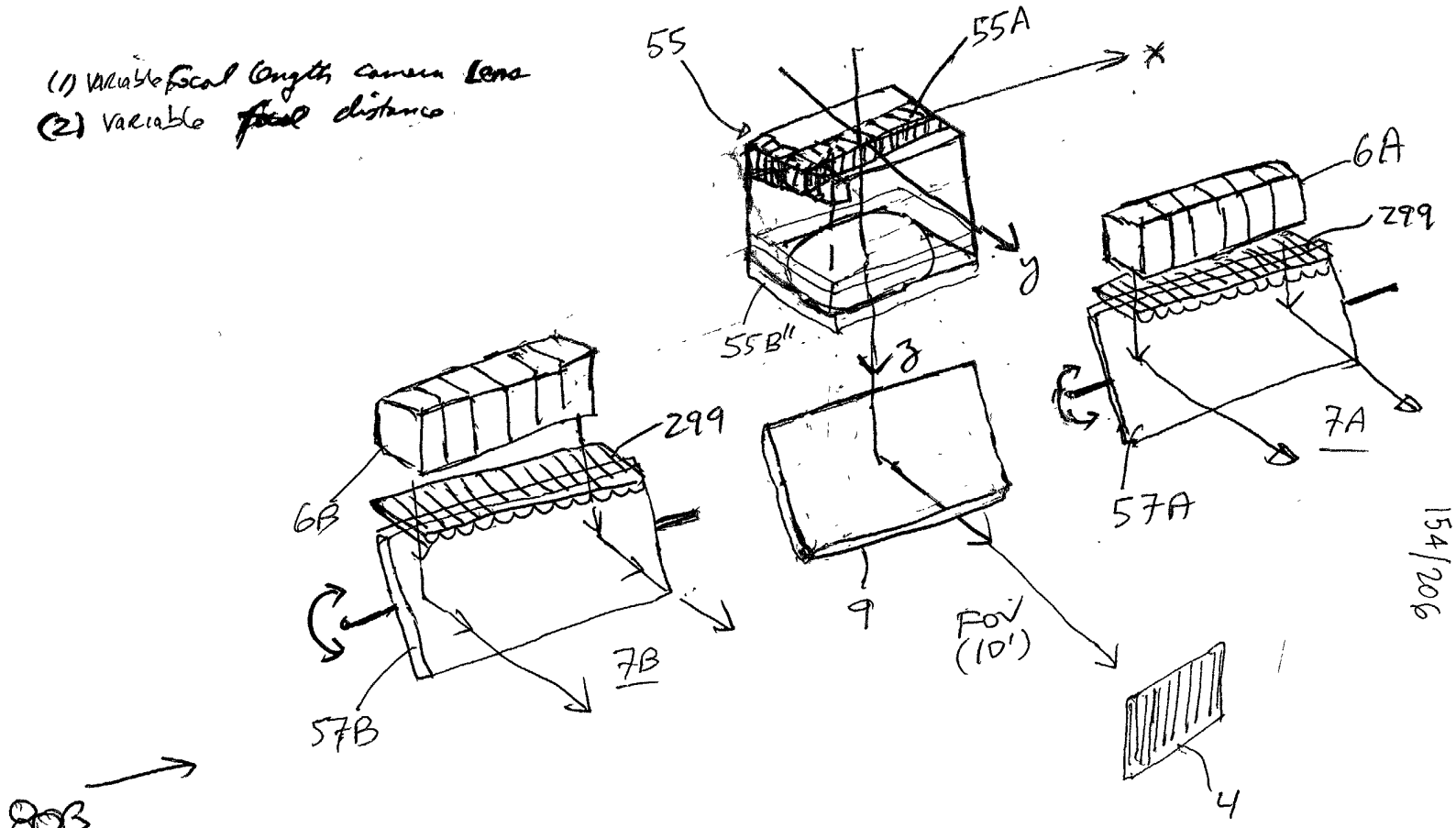


FIG. 6C2

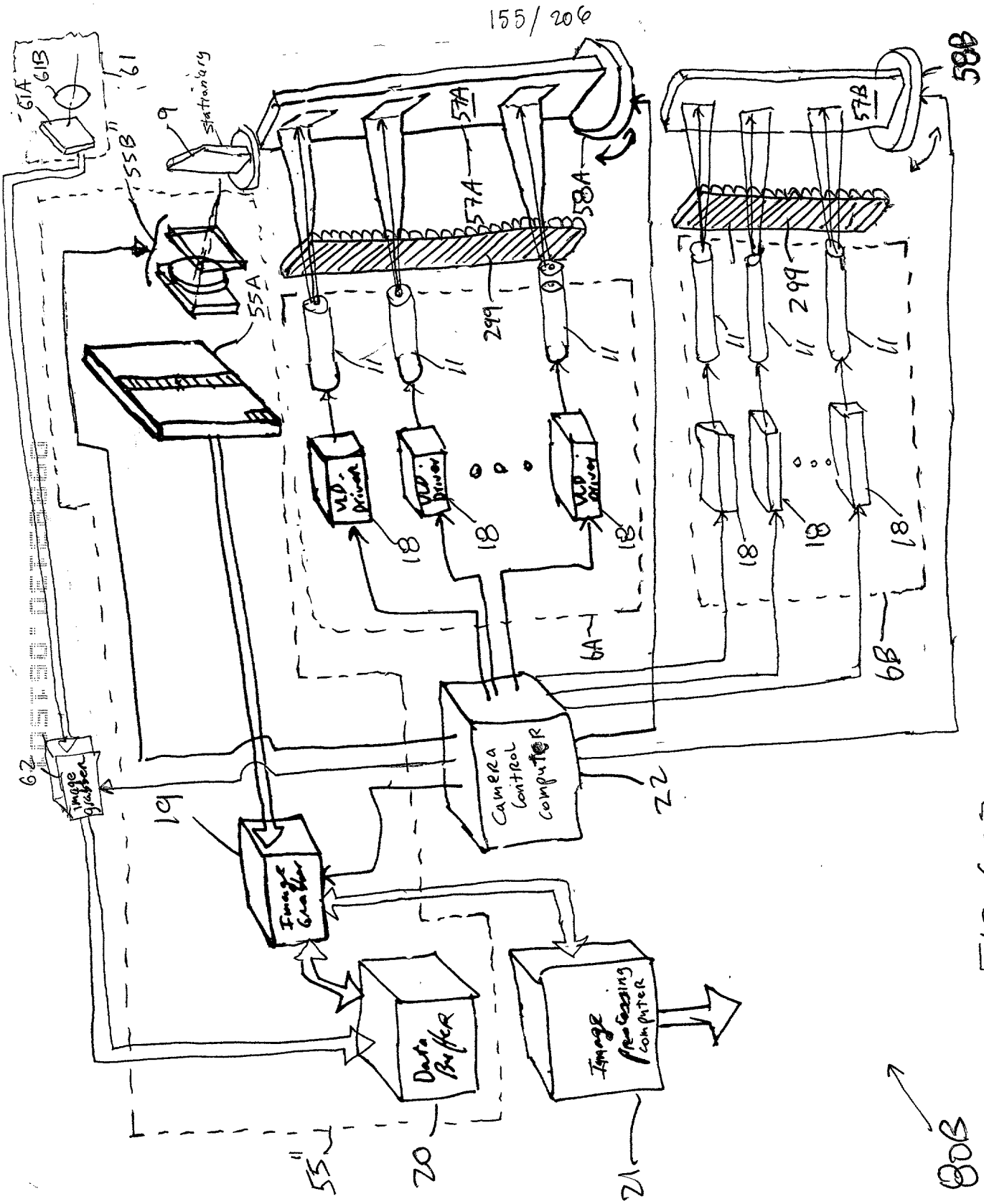
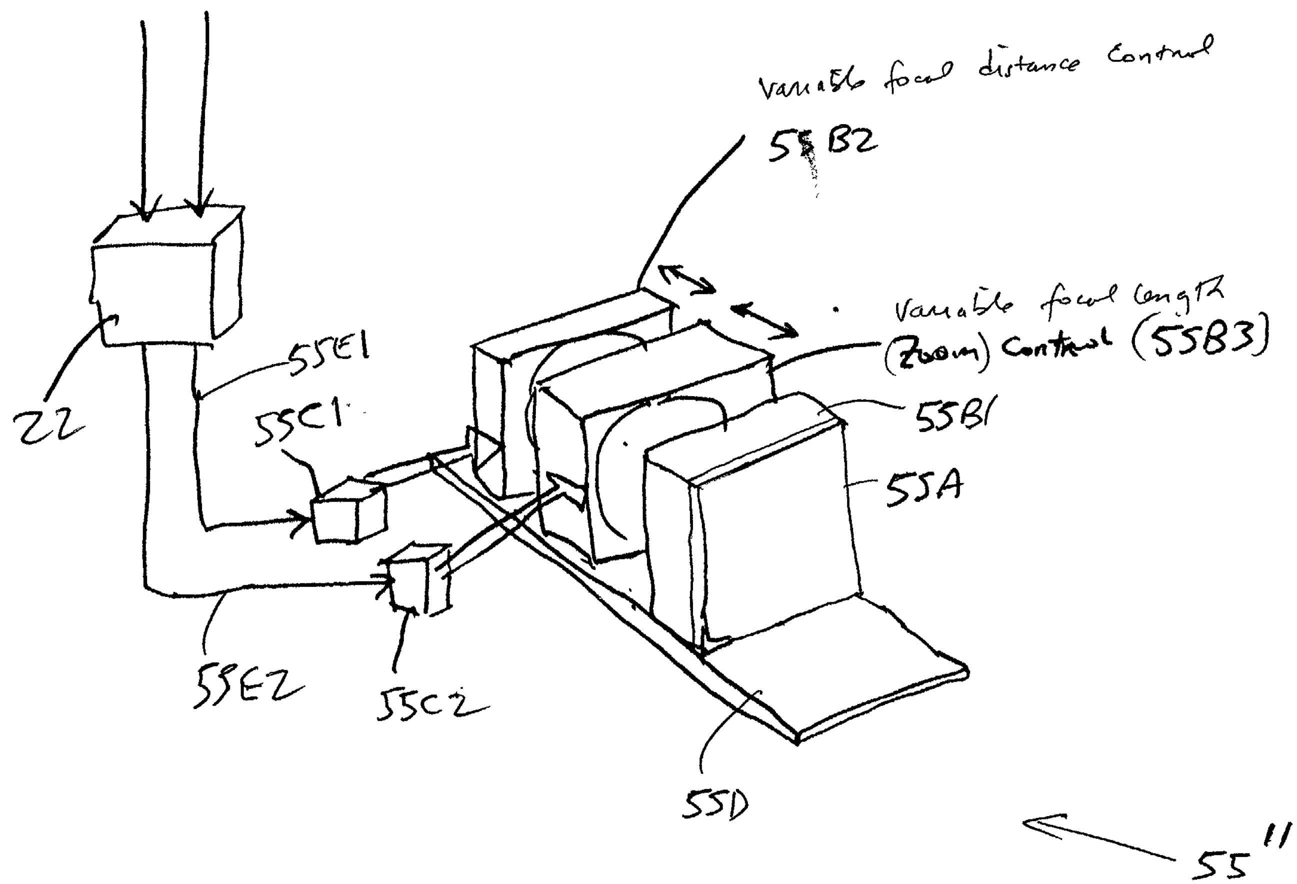

61A
61B
61
9
Stationary
55B
55A
57A
58A
57B
58B
299
18
VLD Driver
62
Image Grabber
19
Frame Grabber
Camera Control Computer
22
6A
6B
Data Buffer
20
Image Processing Computer
21
55
808

FIG. 6C3



Variable focal distance control
55B2
Variable focal length
(Zoom) Control (55B3)
55B1
55A
55D
55E1
55C1
22
55E2
55C2
55"

FIG. 6C4

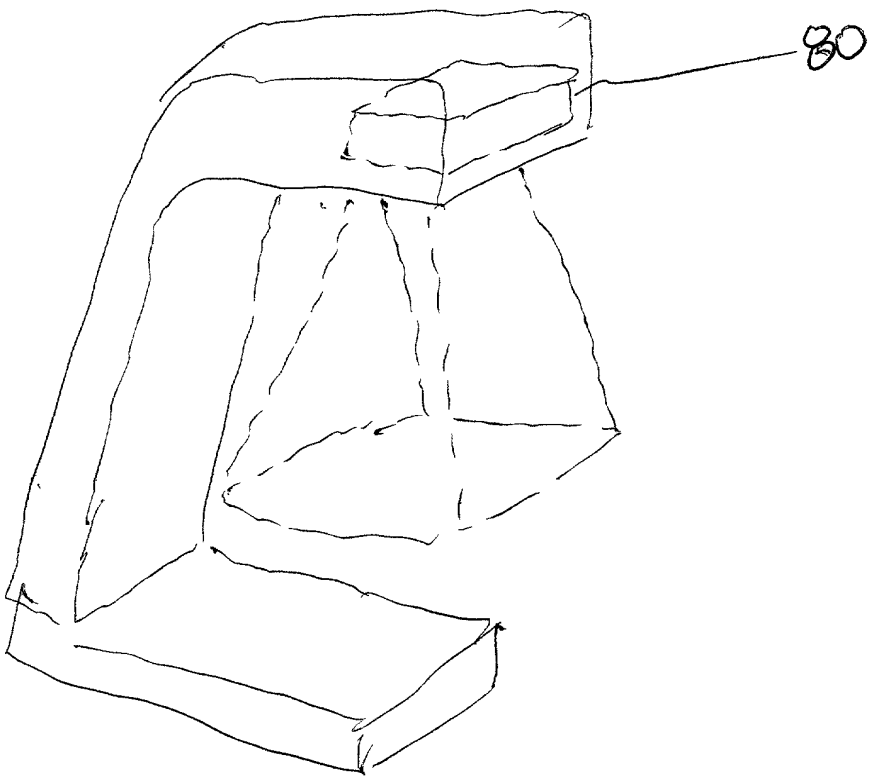


FIG. 6C5

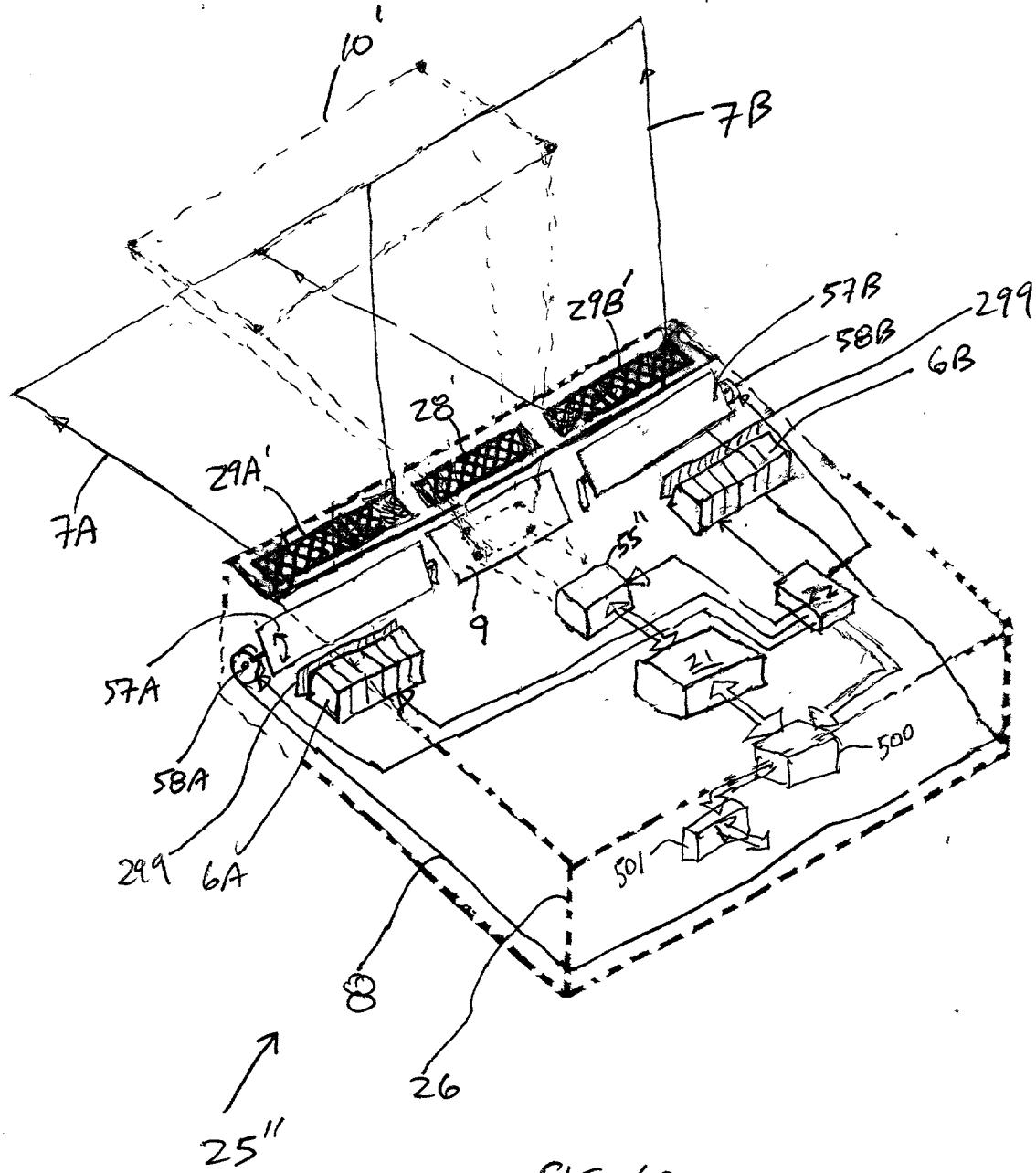

10'
7B
29B'
57B
299
58B
6B
28
29A'
7A
55"
22
9
57A
21
58A
500
299
6A
501
8
26
25"

FIG. 6D1

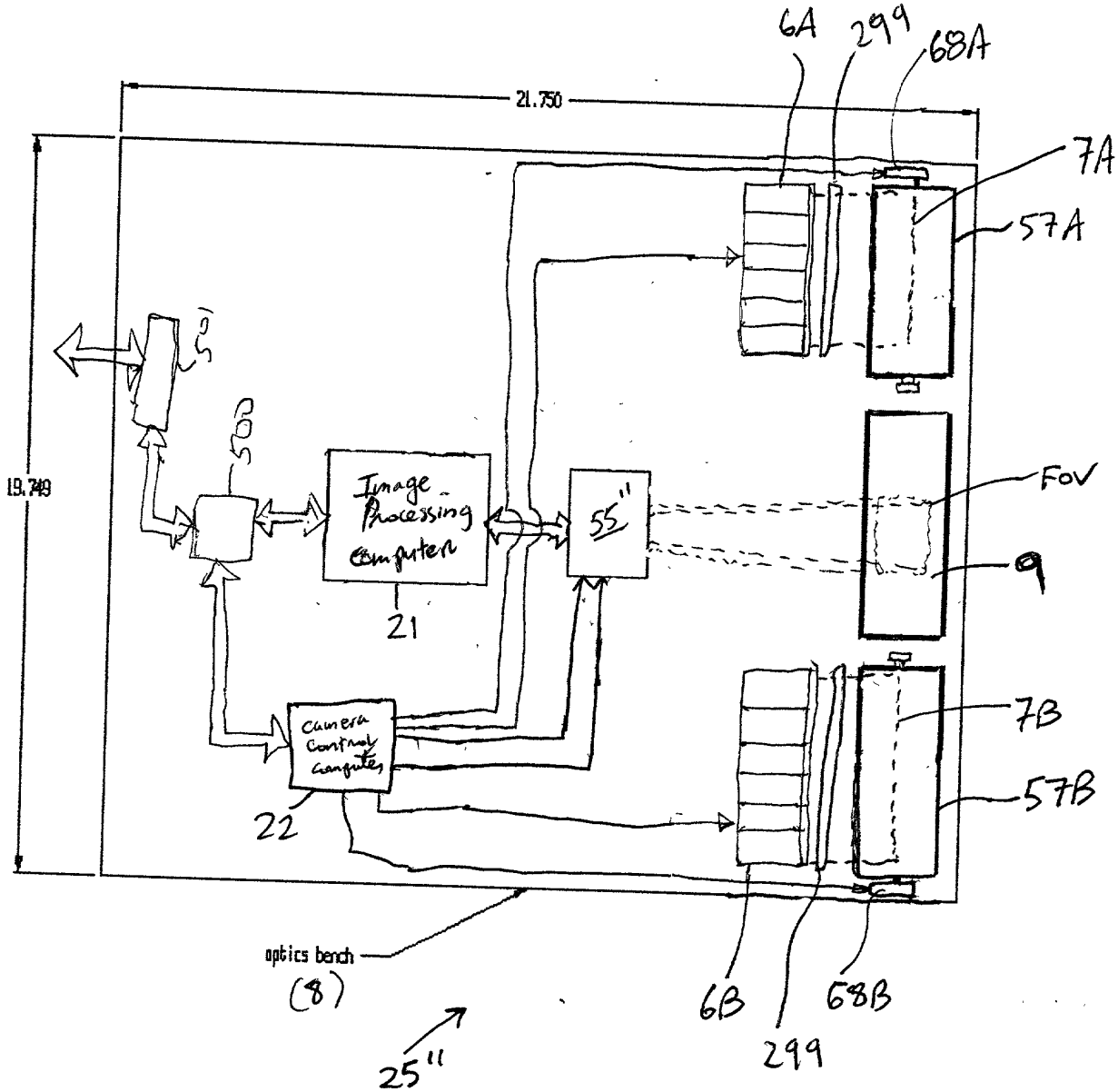

6A
299
68A
21.750
7A
57A
19.749
50
Image Processing Computer
55''
FoV
9
21
7B
57B
Camera Control Computer
22
optics bench
(8)
6B
68B
299
25''

FIG. 6D2

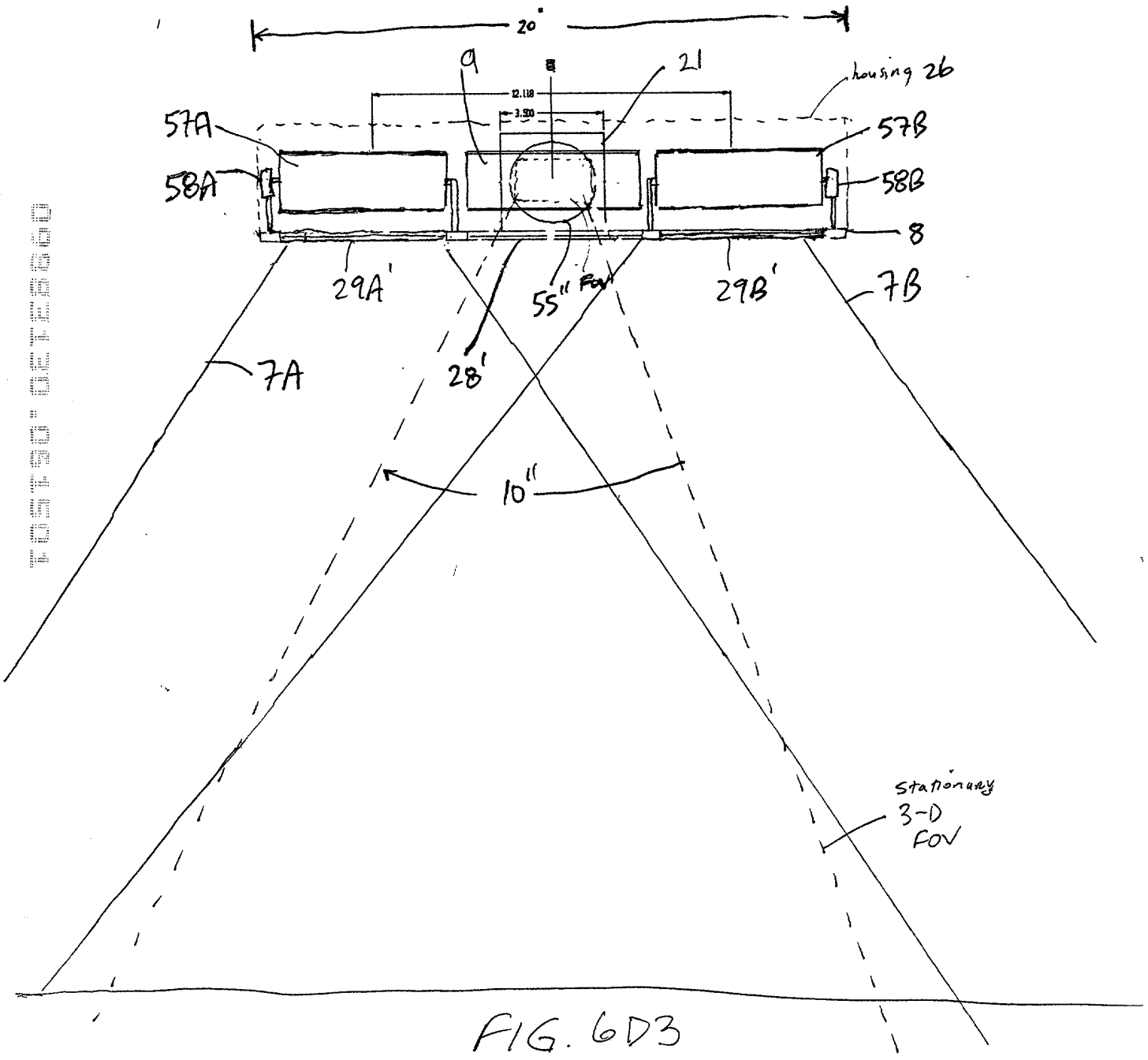

20°
9
21
housing 26
12.118
3.320
57A
57B
58A
58B
8
29A'
55° FOV
29B'
7B
7A
28'
10"
stationary
3-D
FOV

FIG. 6D3

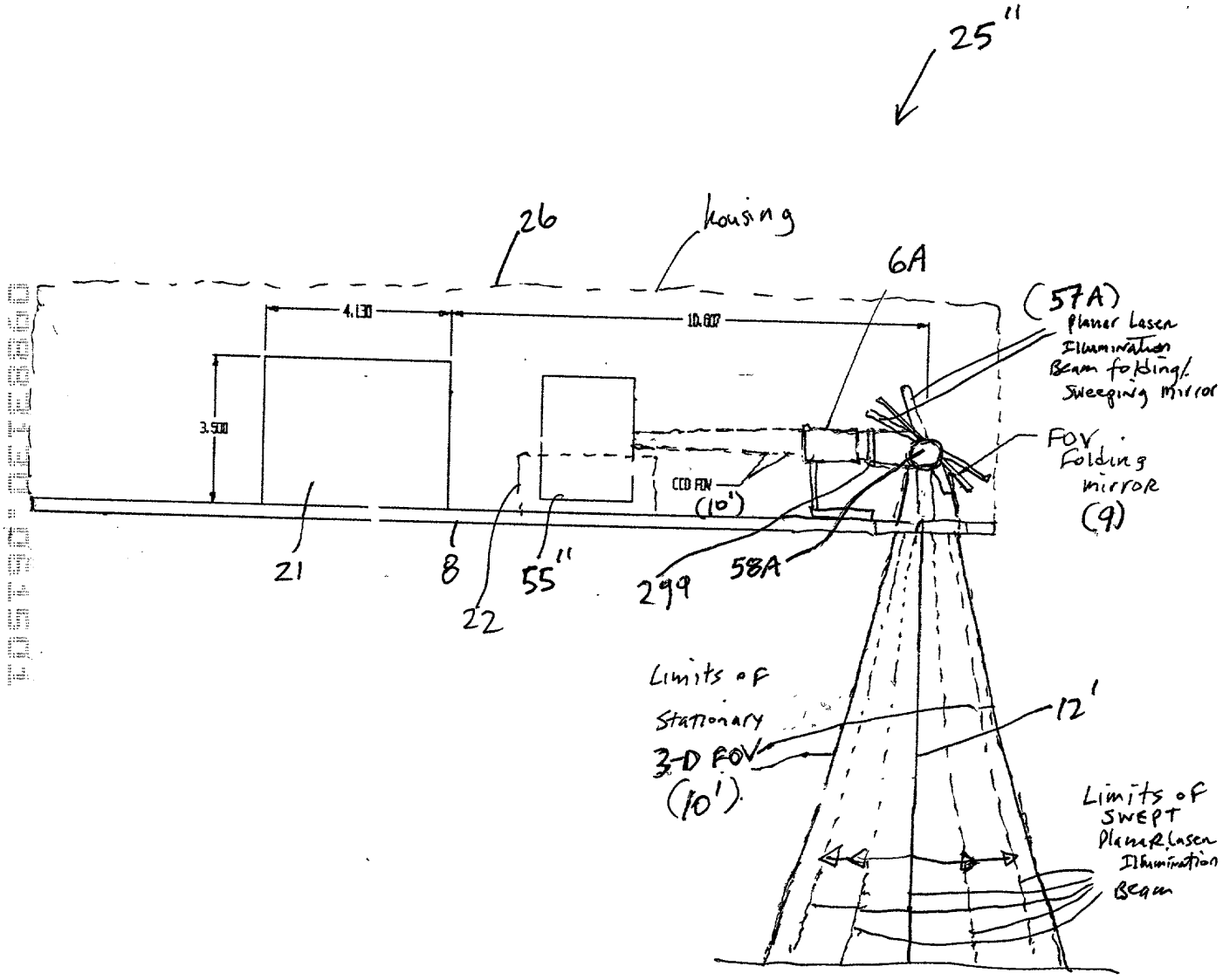

25''
26
housing
6A
(57A)
Planer Laser Illumination Beam folding/ sweeping mirror
4.130
10.607
3.500
FOV folding mirror (9)
CCD FOV (10')
21
8
22
55''
299
58A
Limits of Stationary 3-D FOV (10')
12'
Limits of SWEPT Planer Laser Illumination Beam

FIG. 6D4

variable FOV

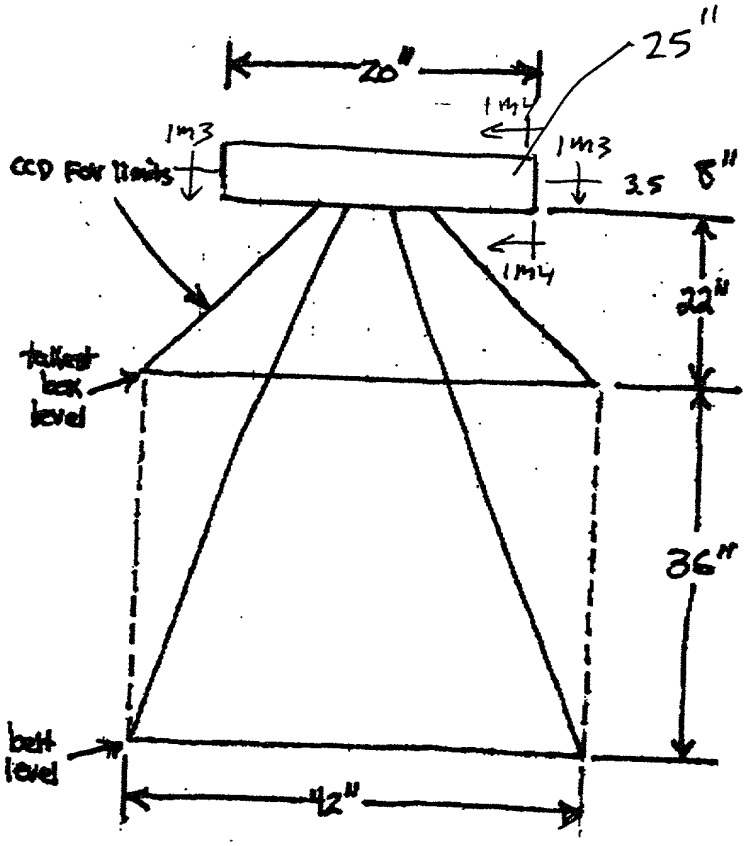


FIG. 6D5

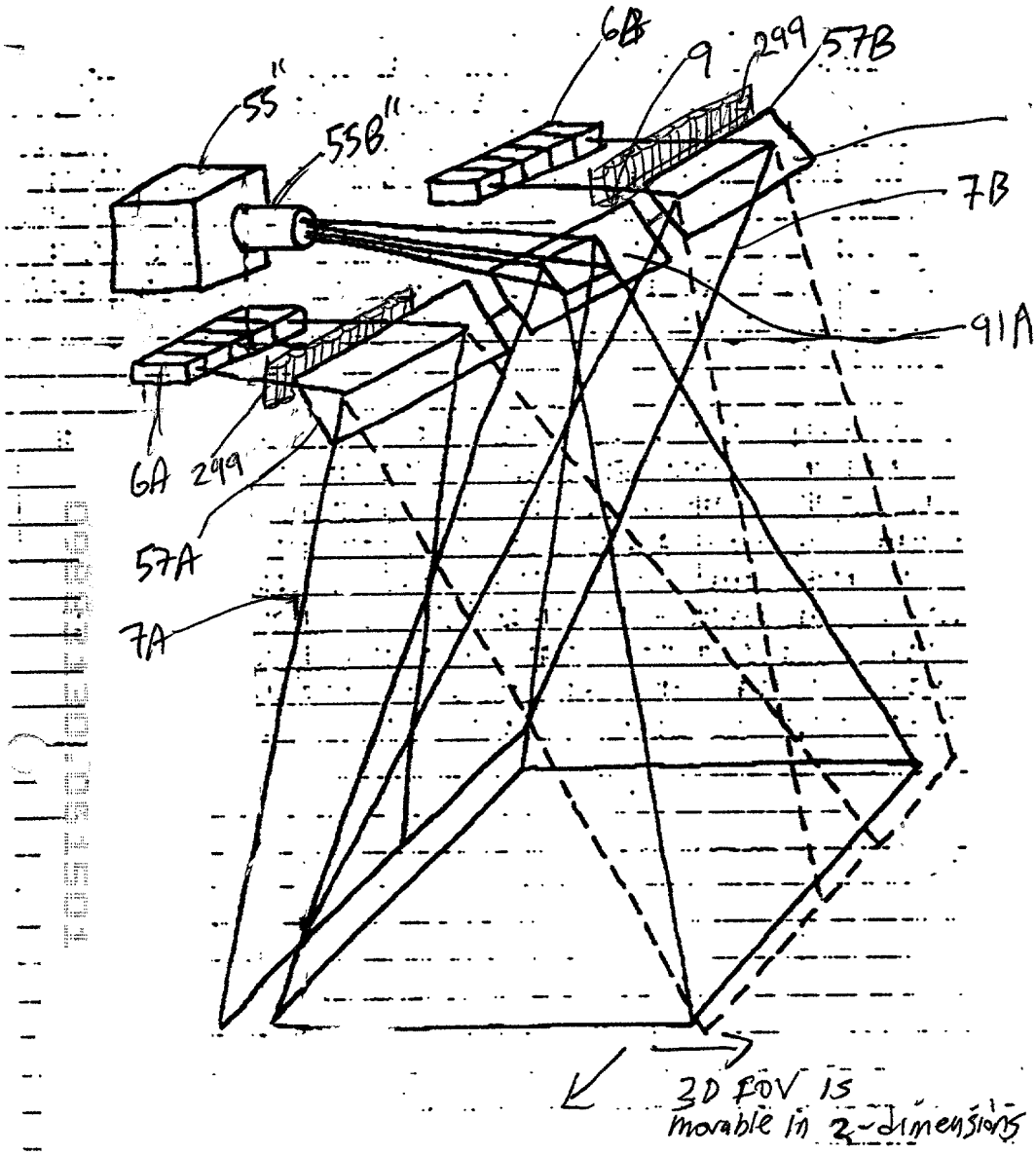

6B
9
299
57B
55"
55B"
7B
91A
90
6A
299
57A
7A
3D FOV is
movable in 2-dimensions

FIG. 6E1

(1) Variable focal length camera lens
(2) variable focal distance

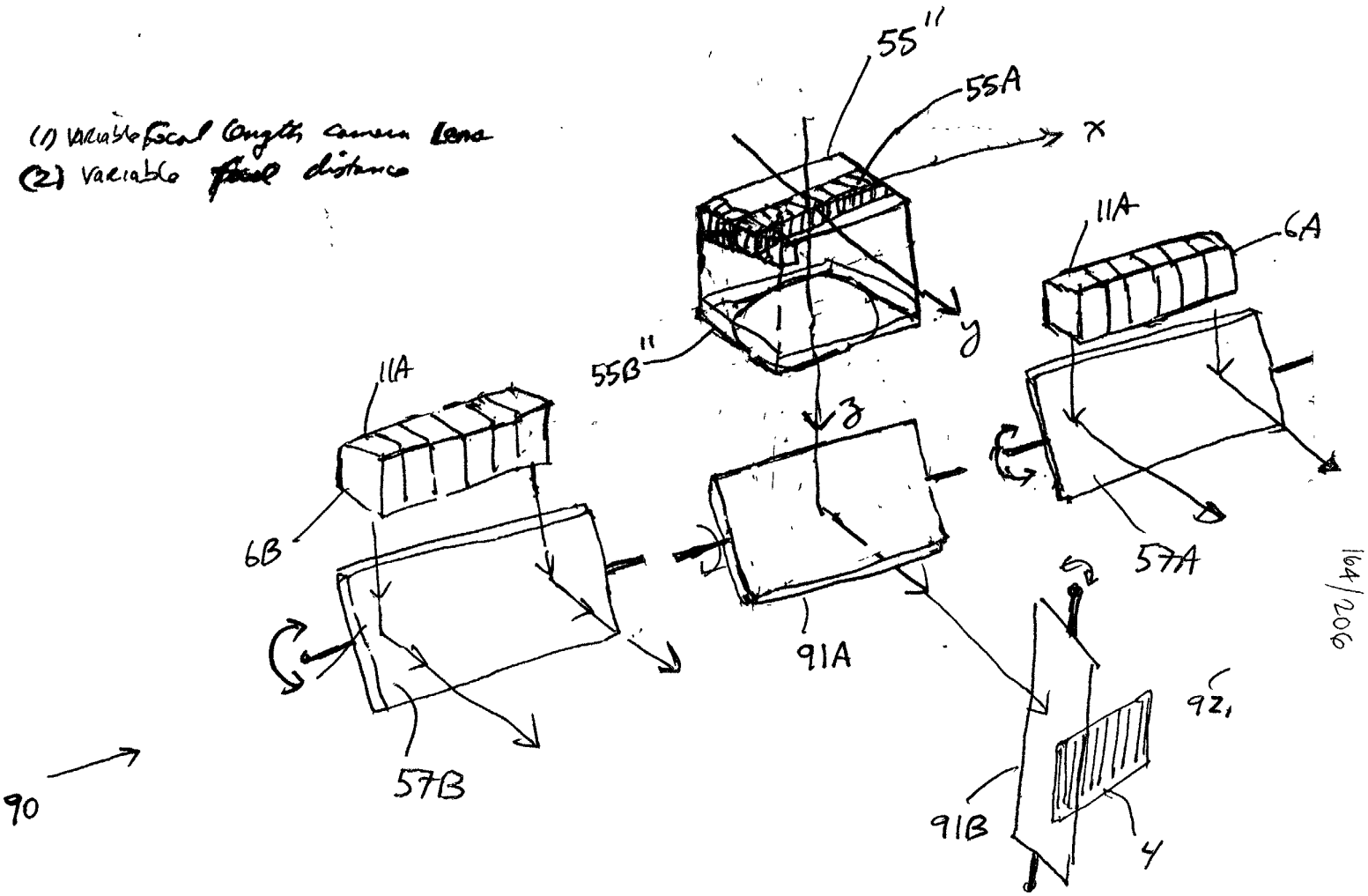


FIG. 6E2

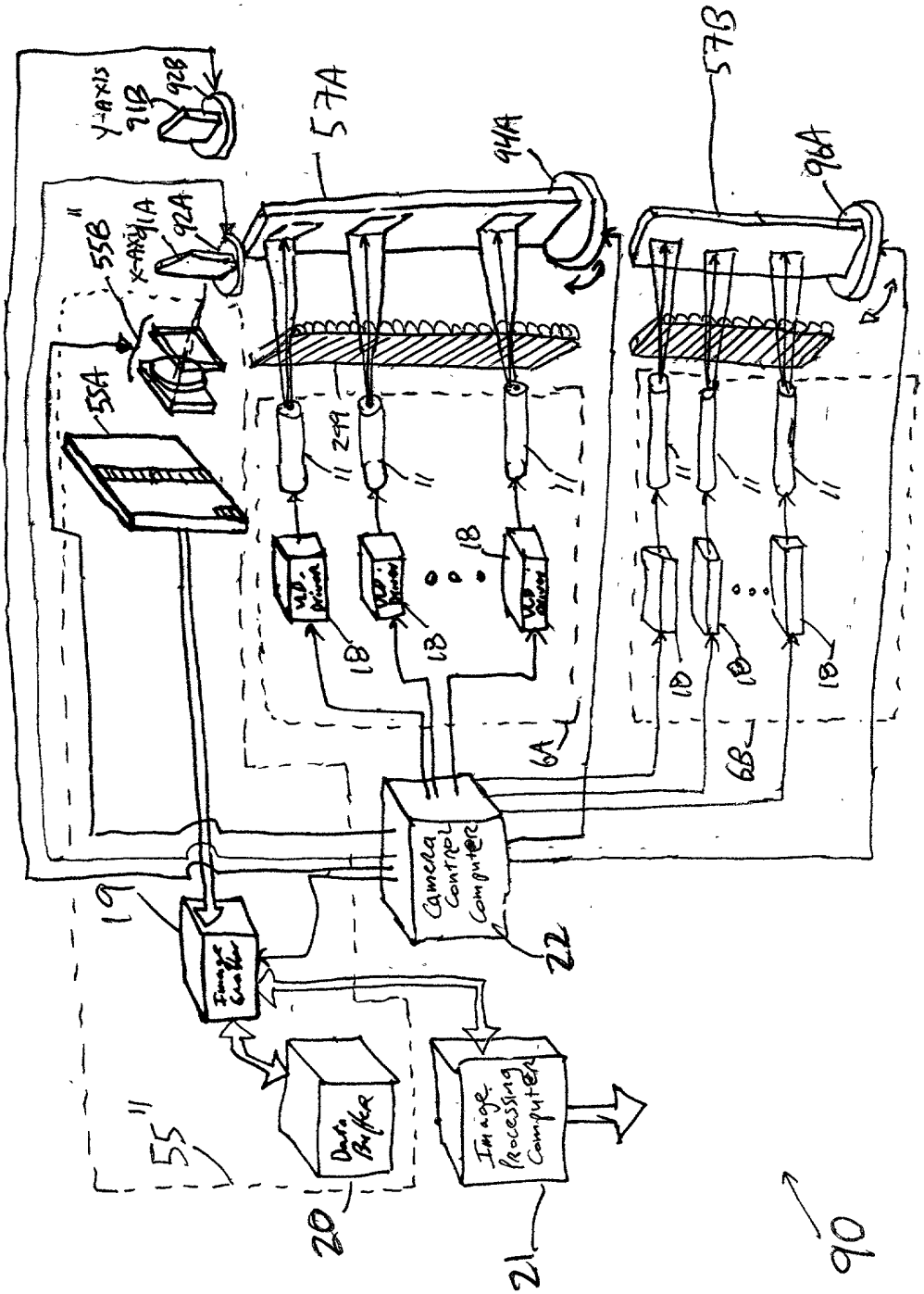

Y-AXIS
92B
92A
55B
X-AXIS
55A
57A
57B
94A
96A
Z
18
18
18
18
18
18
6A
6B
Camera Control Computer
22
19
Image Buffer
Data Buffer
55
20
Image Processing Computer
21
90

FIG. 6E3

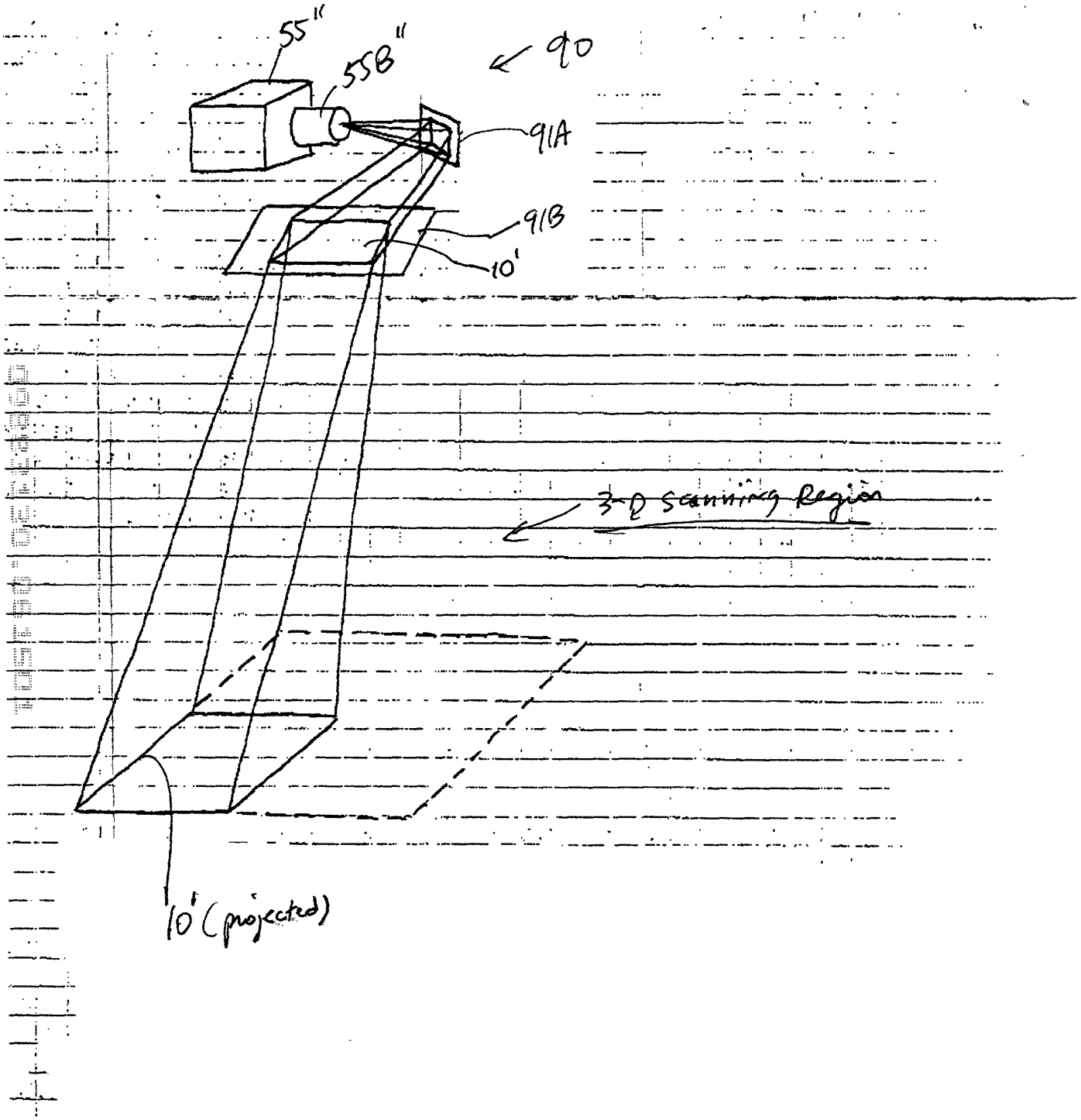


FIG. 6E4

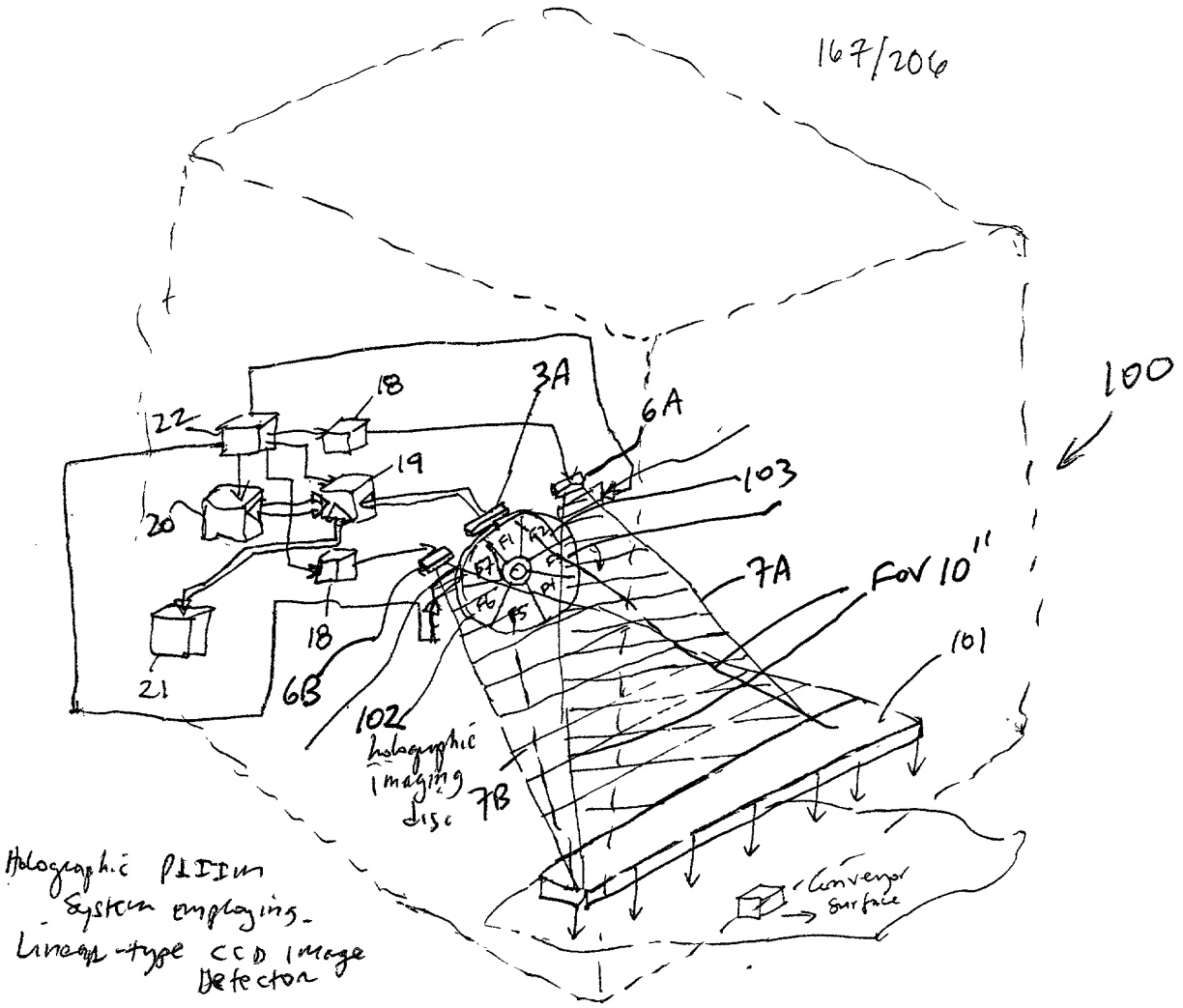

100
22
18
3A
6A
19
103
20
7A
FoV 10''
18
101
21
6B
102
holographic imaging disc
7B
Holographic PLIIM System employing Linear-type CCD Image Detector
Conveyor surface

FIG. 7A

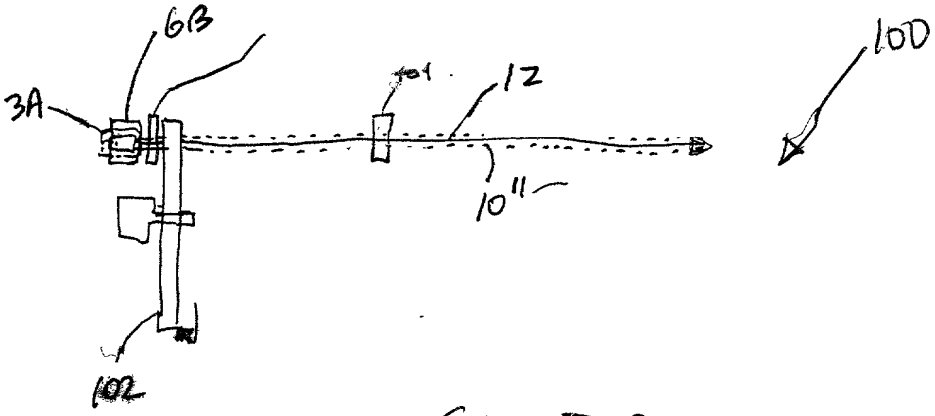

6B
100
3A
12
10''
102

FIG. 7B

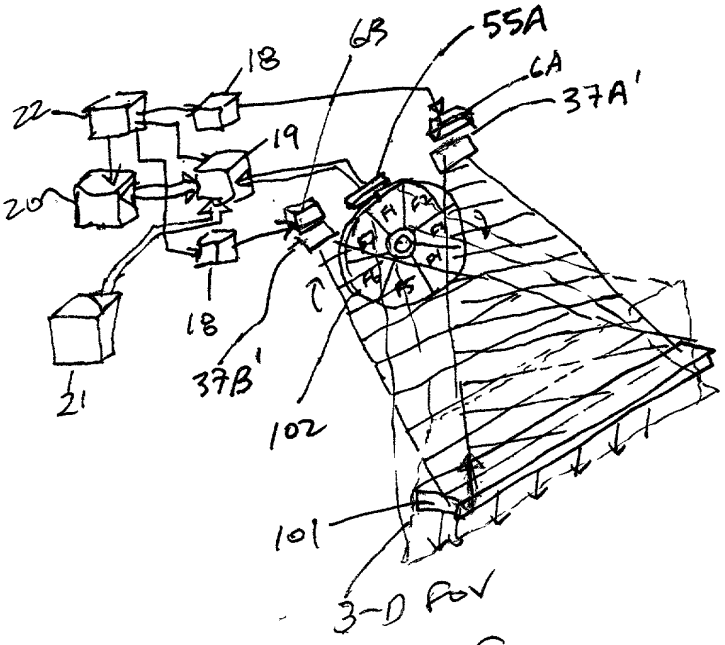

18
6B
55A
CA
37A'
22
19
20
18
37B'
21
102
101
3-D FOV
Holographic PLIIM System employing Area-Type CCD Image Detector
100

FIG. 8A

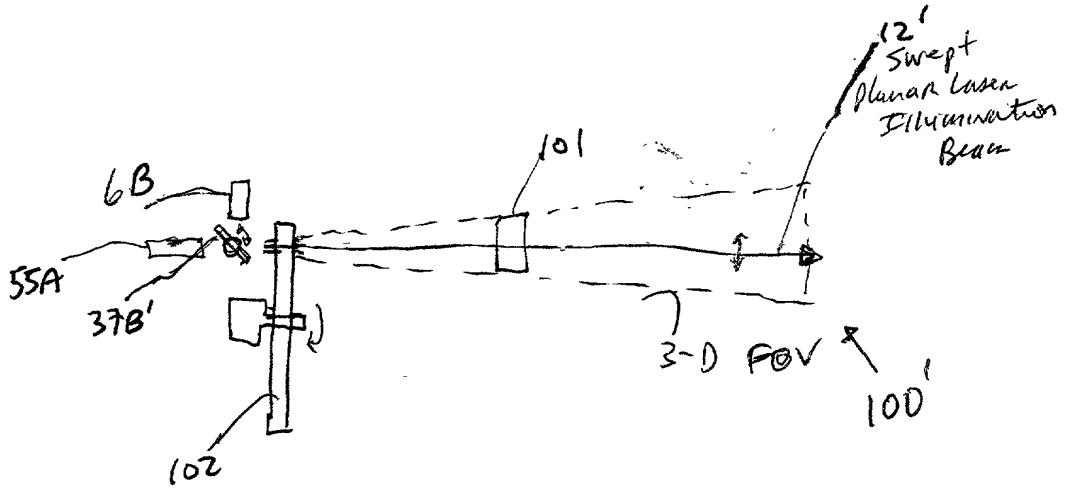

12'
Swept Planar Laser Illumination Beam
101
6B
55A
37B'
102
3-D FOV
100'

FIG. 8B

1-D CCD SCANNER EMBODIMENT

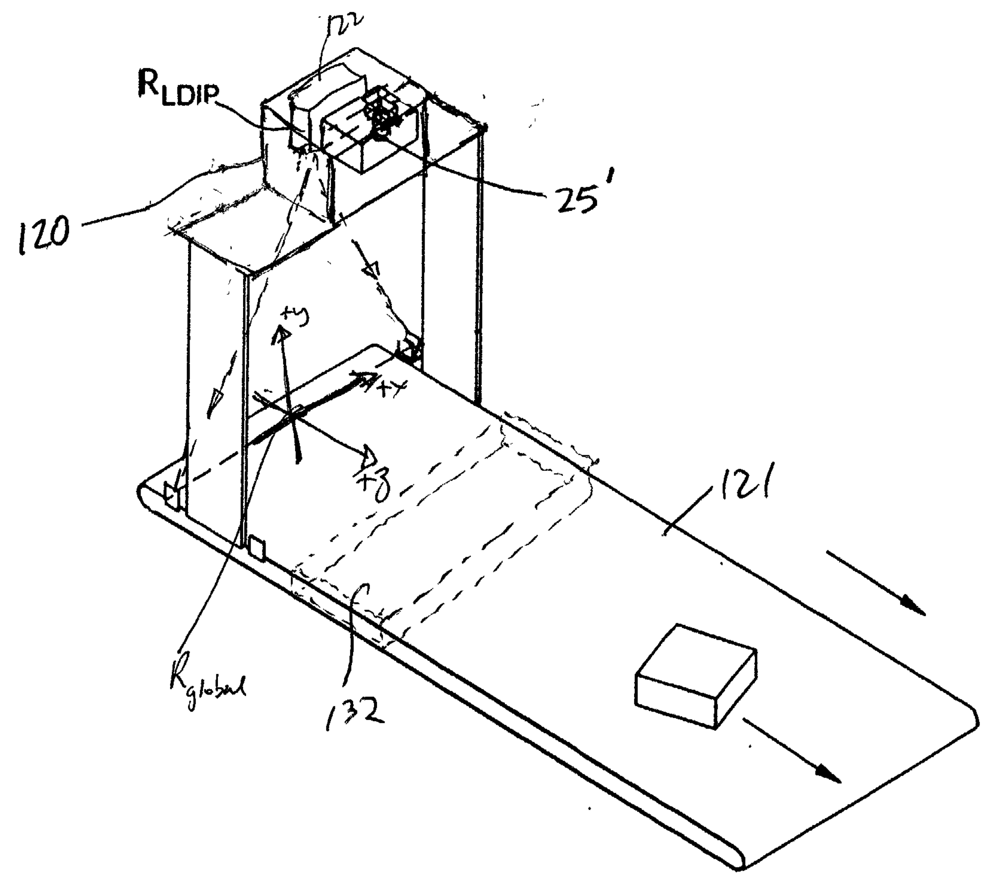


FIG. 9

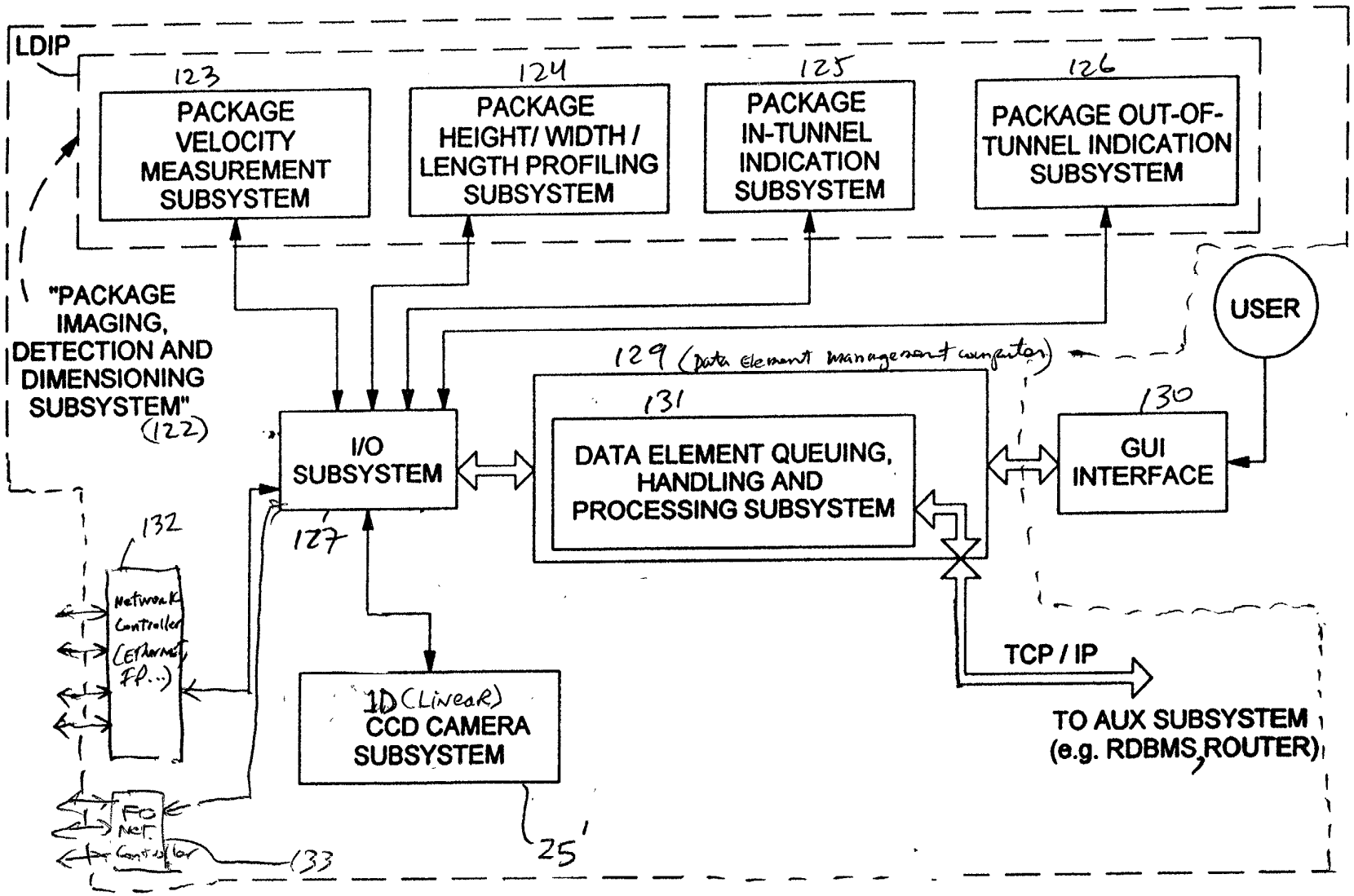

LDIP
123
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124
PACKAGE HEIGHT/ WIDTH / LENGTH PROFILING SUBSYSTEM
125
PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
126
PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
"PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM" (122)
USER
129 (Data Element Management Computer)
131
I/O SUBSYSTEM
DATA ELEMENT QUEUING, HANDLING AND PROCESSING SUBSYSTEM
130
GUI INTERFACE
127
132
Network Controller (Ethernet, FP...)
1D (Linear) CCD CAMERA SUBSYSTEM
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)
FO Net. Controller
133
25'
170/206
120

FIG. 10

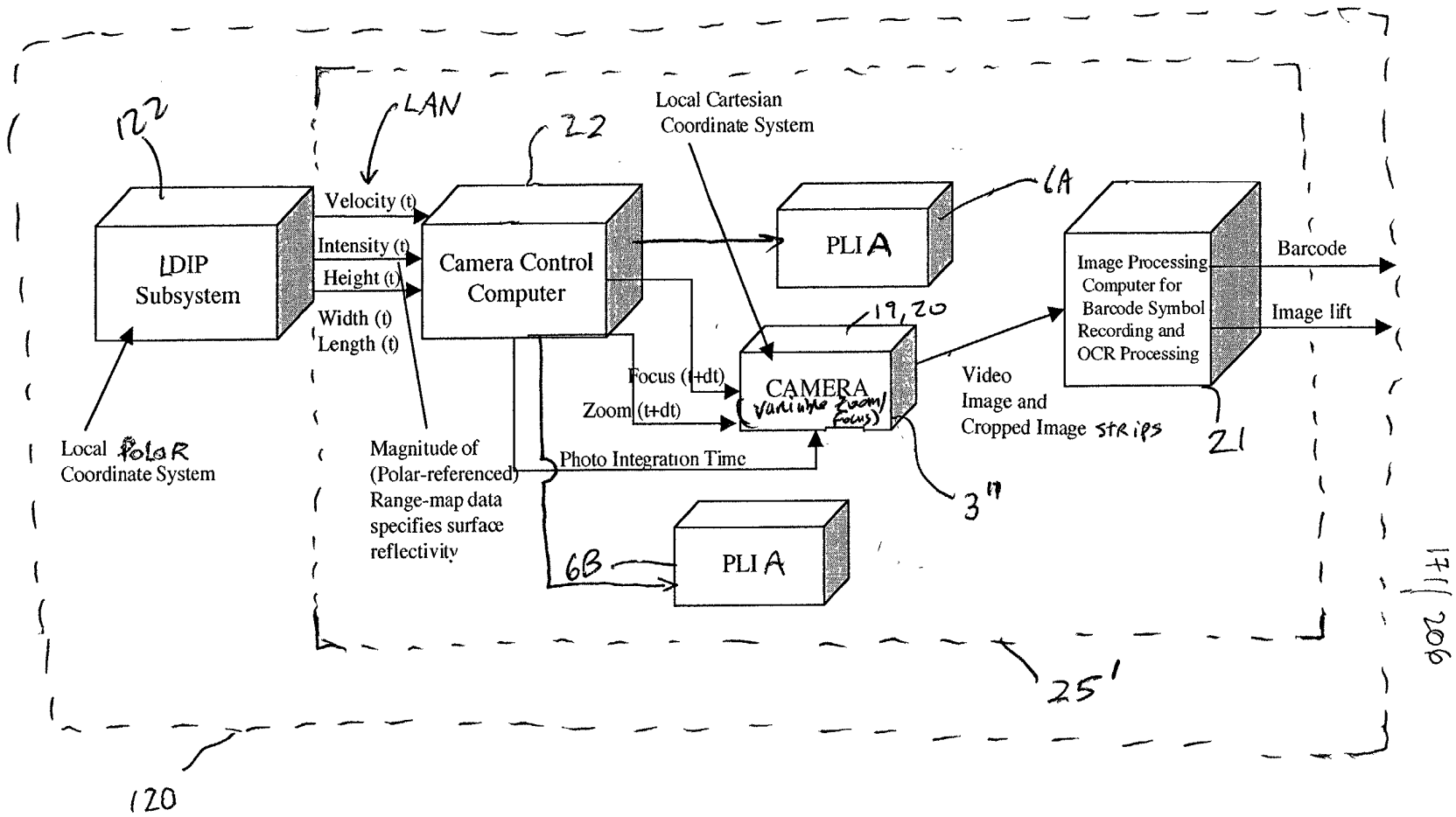


FIG. 11

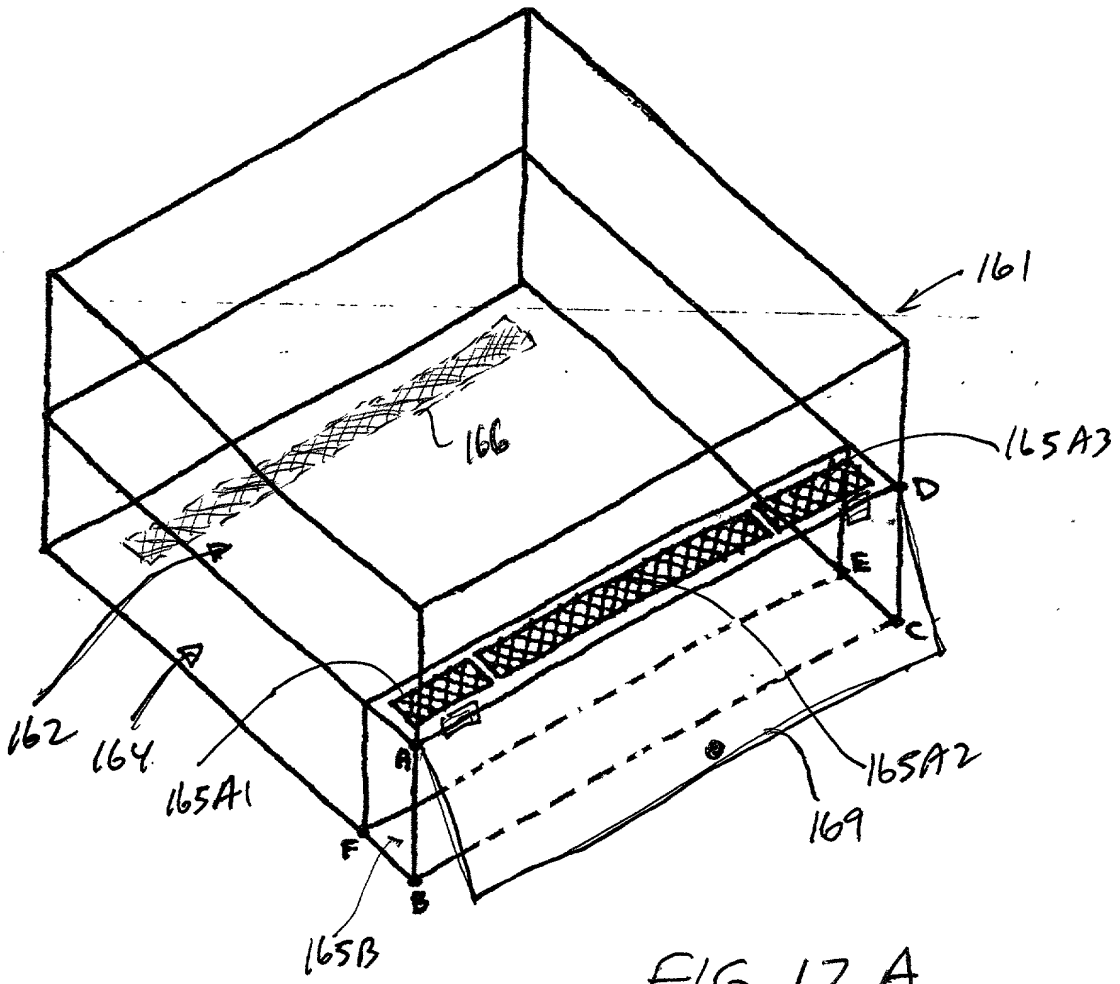


FIG. 12A

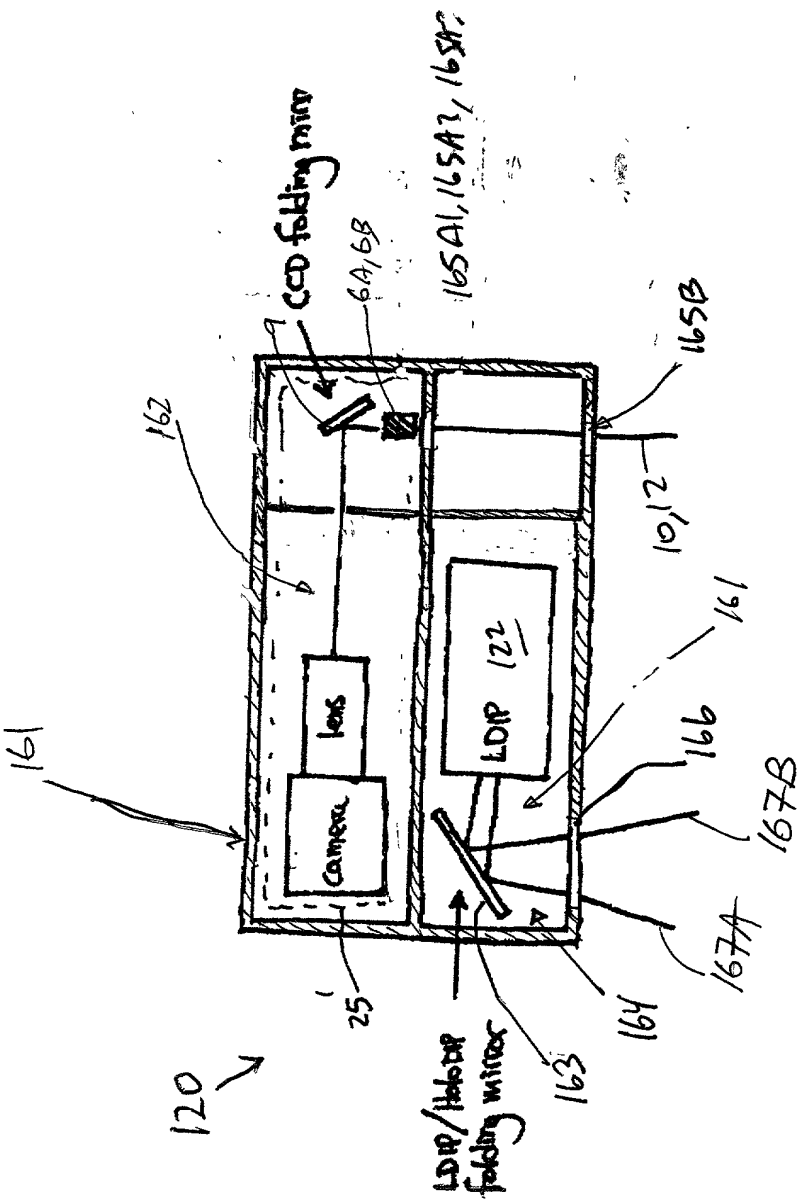

CCD folding mirror
64,68
165A1, 165A2, 165B
165B
162
101,102
161
LDP 122
Lens
Camera
166
167B
167A
161
25
164
163
LDP/Hologram folding mirror
120

FIG. 12B

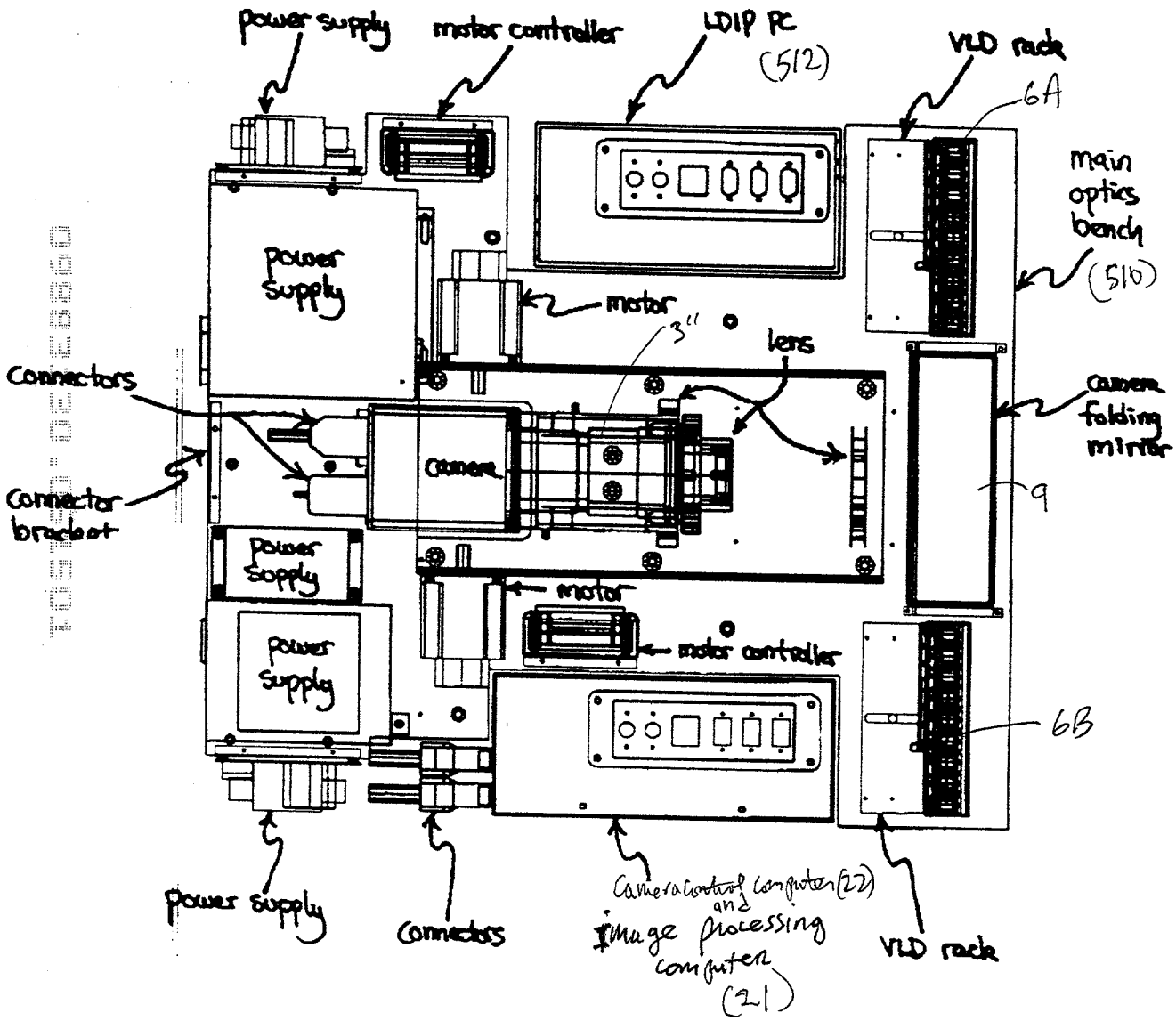

power supply
motor controller
LDIP PC
(512)
VLD rack
6A
main optics bench
(510)
power supply
motor
3"
lens
Connectors
camera folding mirror
camera
Connector bracket
9
power supply
power supply
motor
motor controller
6B
power supply
Connectors
Camera control computer (22) and image processing computer (21)
VLD rack

FIG. 12C

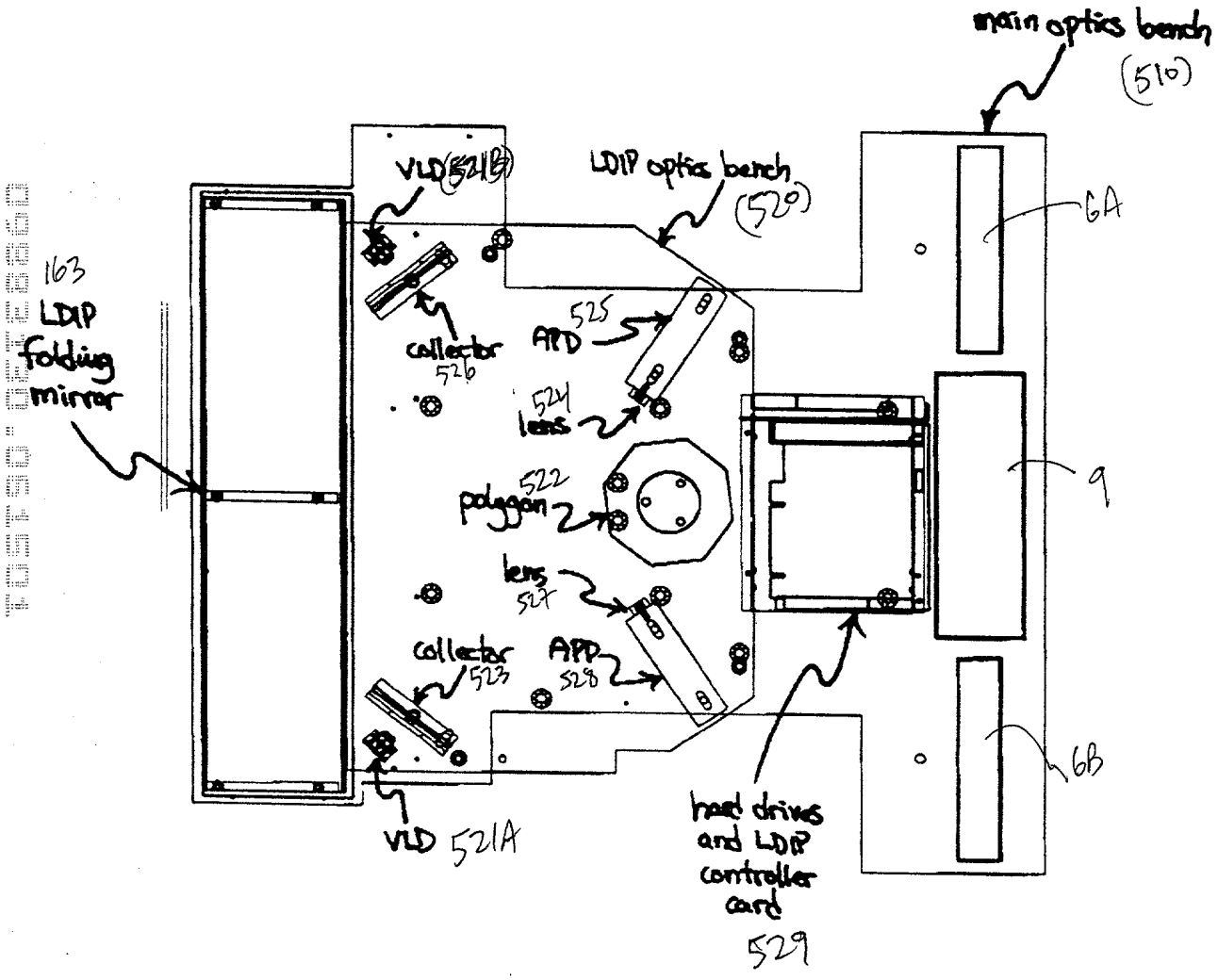
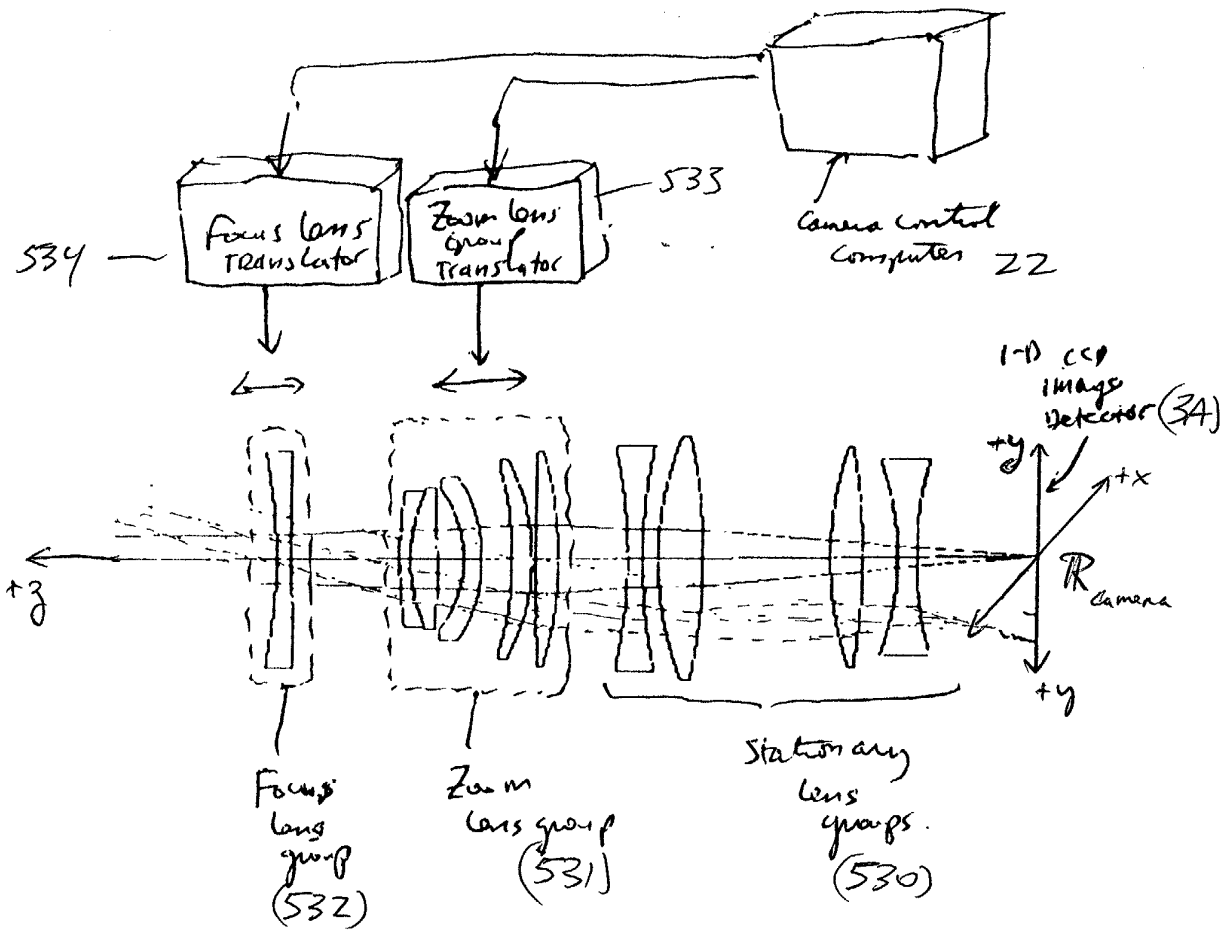

main optics bench
(510)
VLD (521B)
LDIP optics bench
(520)
6A
163
LDIP
folding
mirror
collector
526
APD
525
524
lens
9
polygon
522
lens
527
collector
523
APD
528
6B
VLD 521A
host drives
and LDIP
controller
card
529

FIG. 12D



(main optics)
(Lens groups)

FIG. 12E

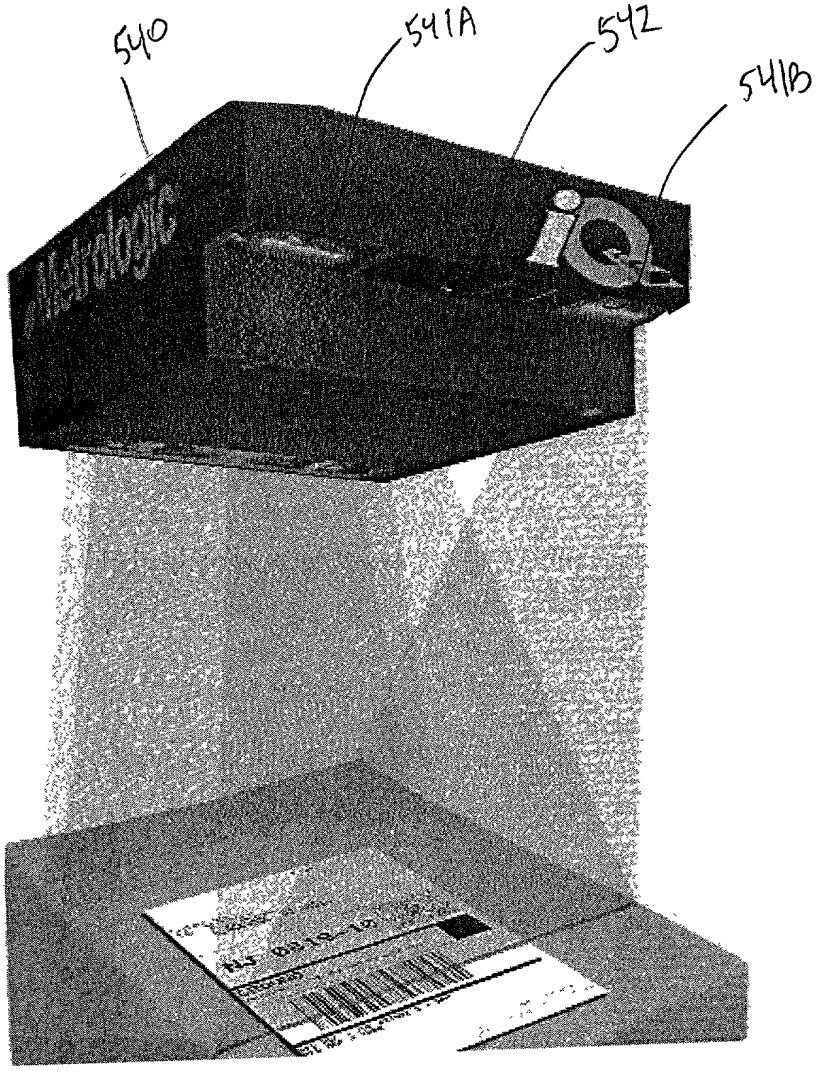


FIG. 13A

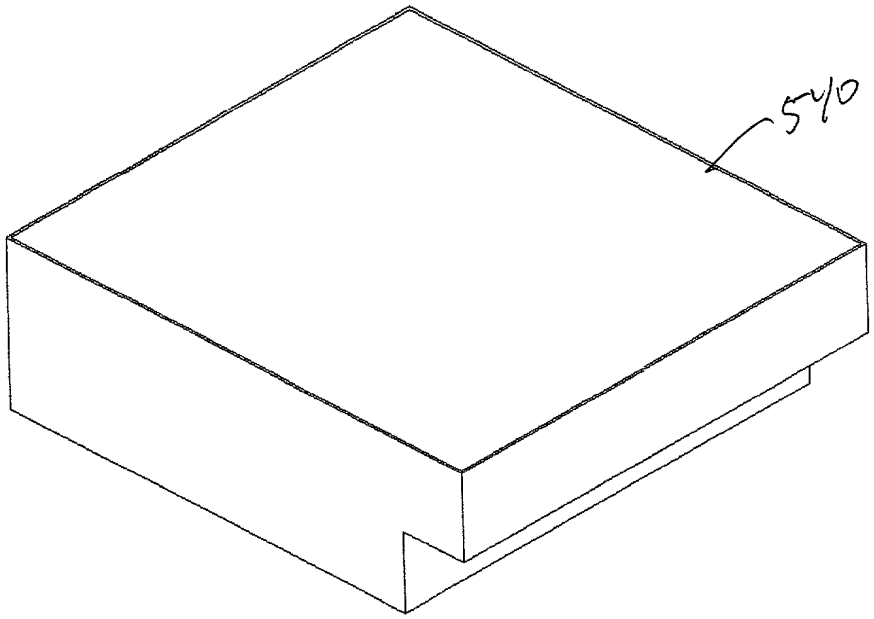


FIG. 13B

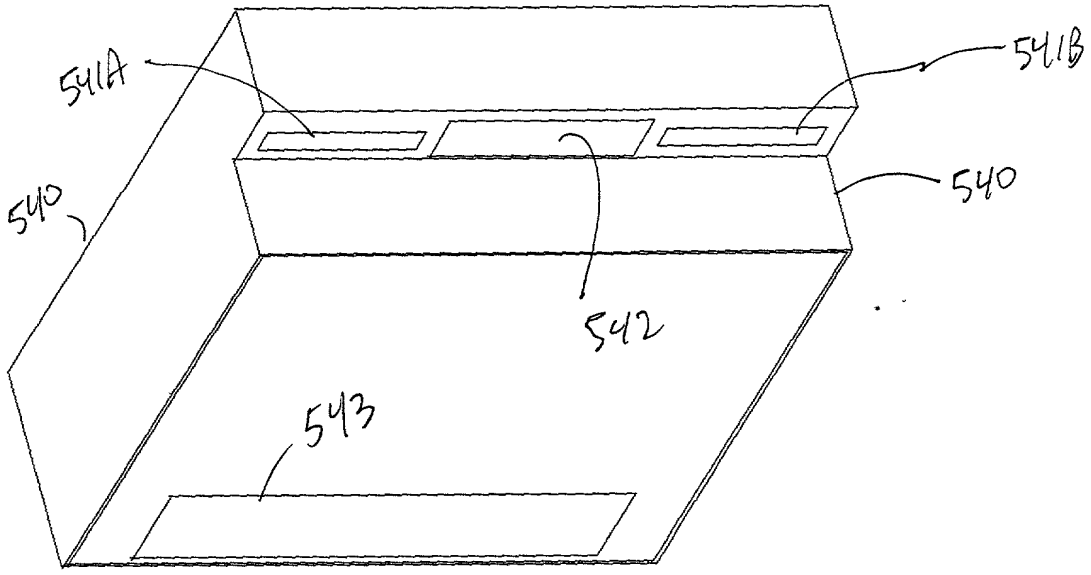


FIG. 13C

PLLIM-BASED PACKAGE IDENTIFICATION AND DIMENSIONING (PID) SYSTEM

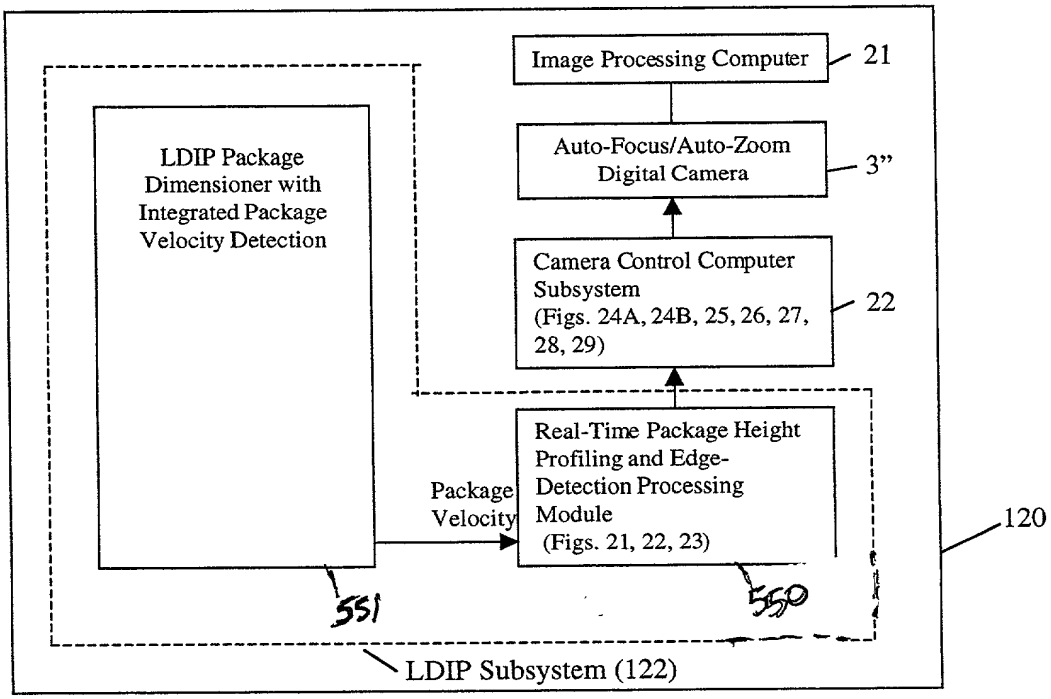


FIG. 14

LDIP REAL-TIME PACKAGE HEIGHT PROFILE AND EDGE DETECTION METHOD

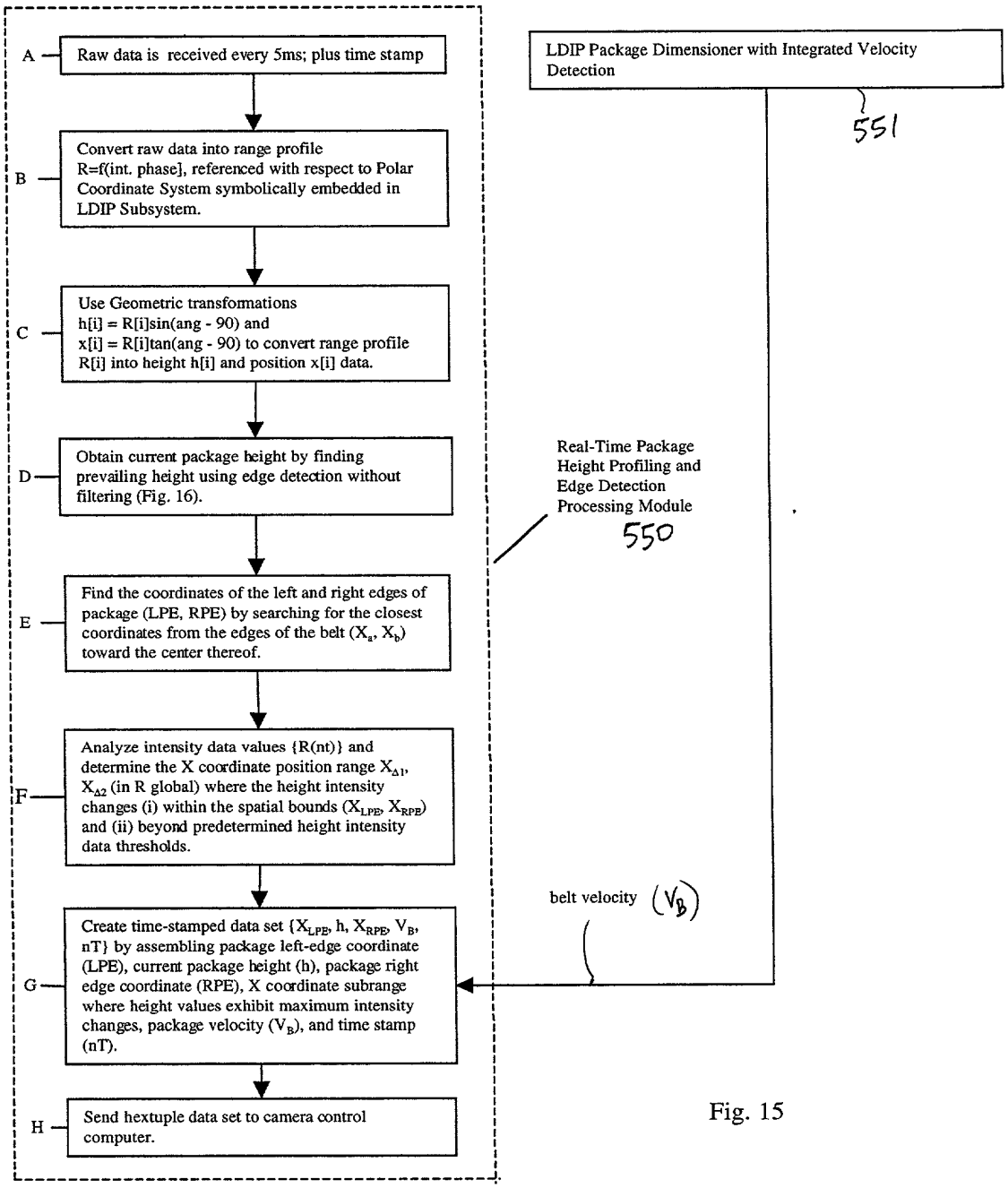
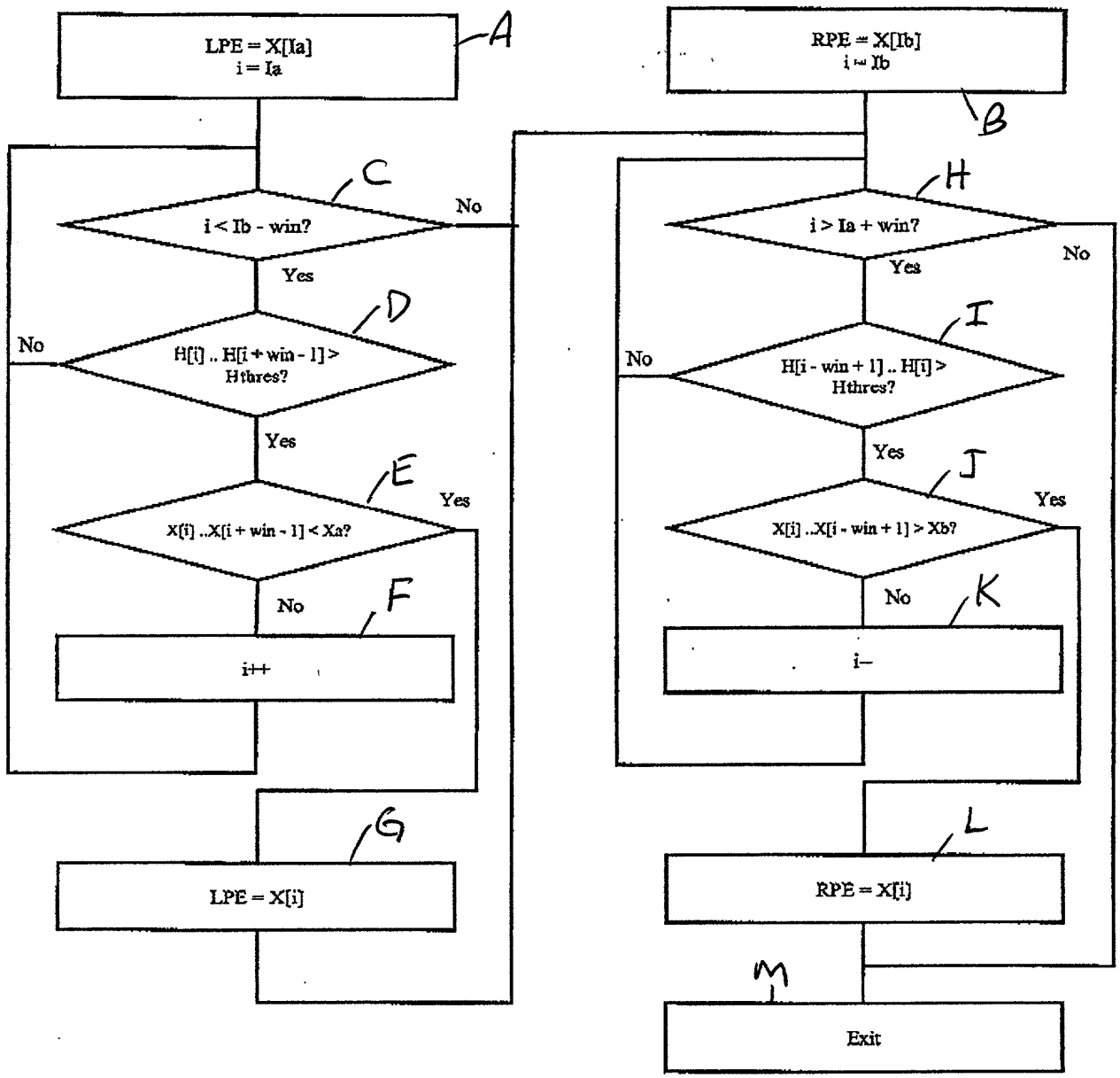


Fig. 15

LDIP Real Time Package Edge Detection



Xa = location of belt left edge; Xb = location of belt right edge
Ia = belt edge edge pixel; Ib = belt right edge pixel
LPE = Left package edge; RPE = Right package edge
H[] = Pixel height array; X[] = Pixel location array
win = package detection window

FIG. 16

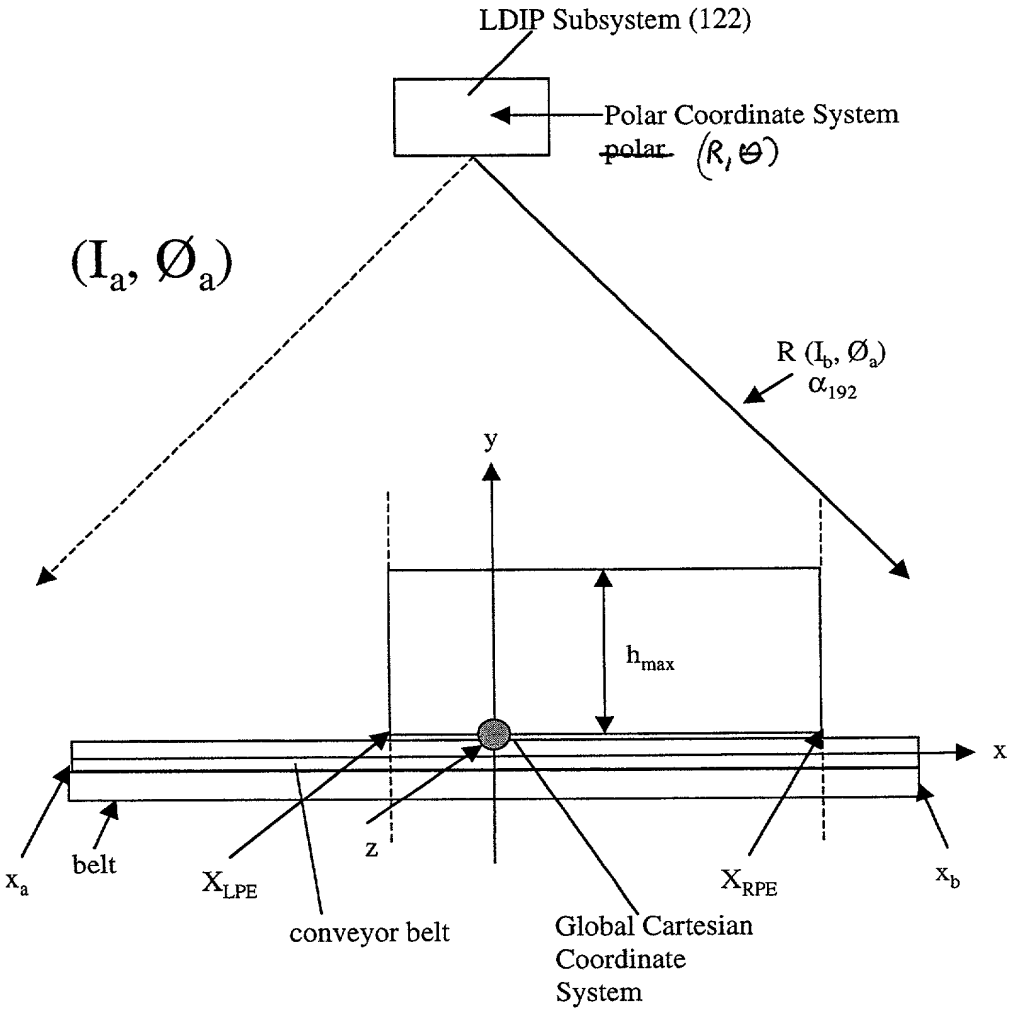

LDIP Subsystem (122)
Polar Coordinate System
polar (R, θ)
(I_a, Ø_a)
R (I_b, Ø_a)
α_192
y
h_max
x
x_a
belt
X_LPE
z
X_RPE
x_b
conveyor belt
Global Cartesian Coordinate System

Fig. 17

INFORMATION MEASURED AT SCAN ANGLES BEFORE COORDINATE TRANSFORMS

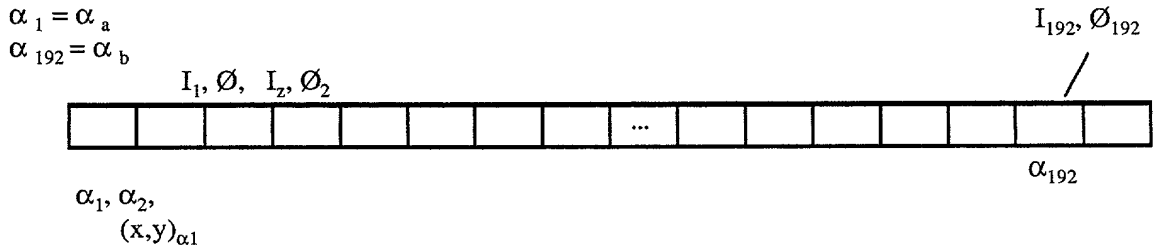


Fig. 17A

RANGE AND POLAR ANGLE MEASURES TAKEN AT SCAN ANGLE α BEFORE COORDINATE TRANSFORMS

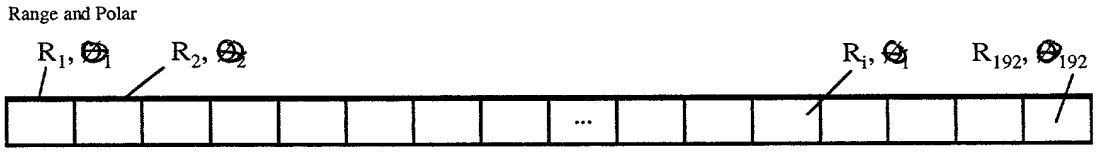


Fig. 17B

MEASURED PACKAGE HEIGHT AND POSITION VALUES AFTER COORDINATE TRANSFORMS

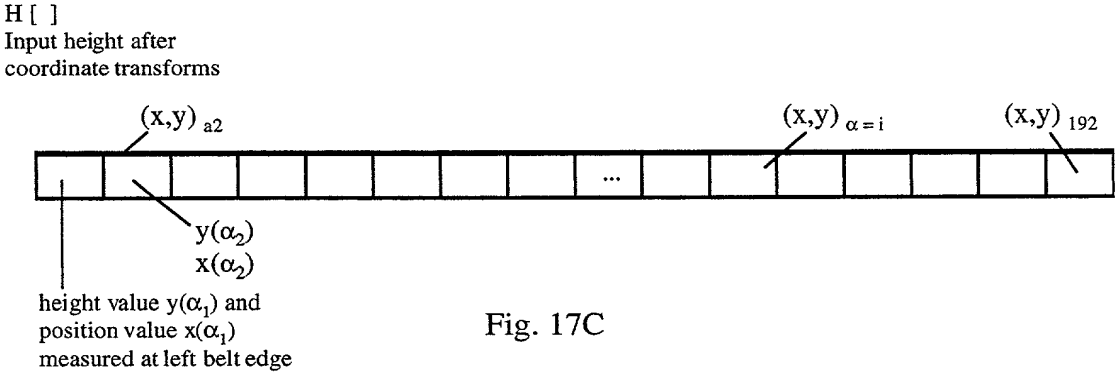


Fig. 17C

CAMERA CONTROL PROCESS CARRIED OUT WITHIN THE CAMERA CONTROL SUBSYSTEM OF EACH OBJECT ATTRIBUTE ACQUISITION AND ANALYSIS SYSTEM

560

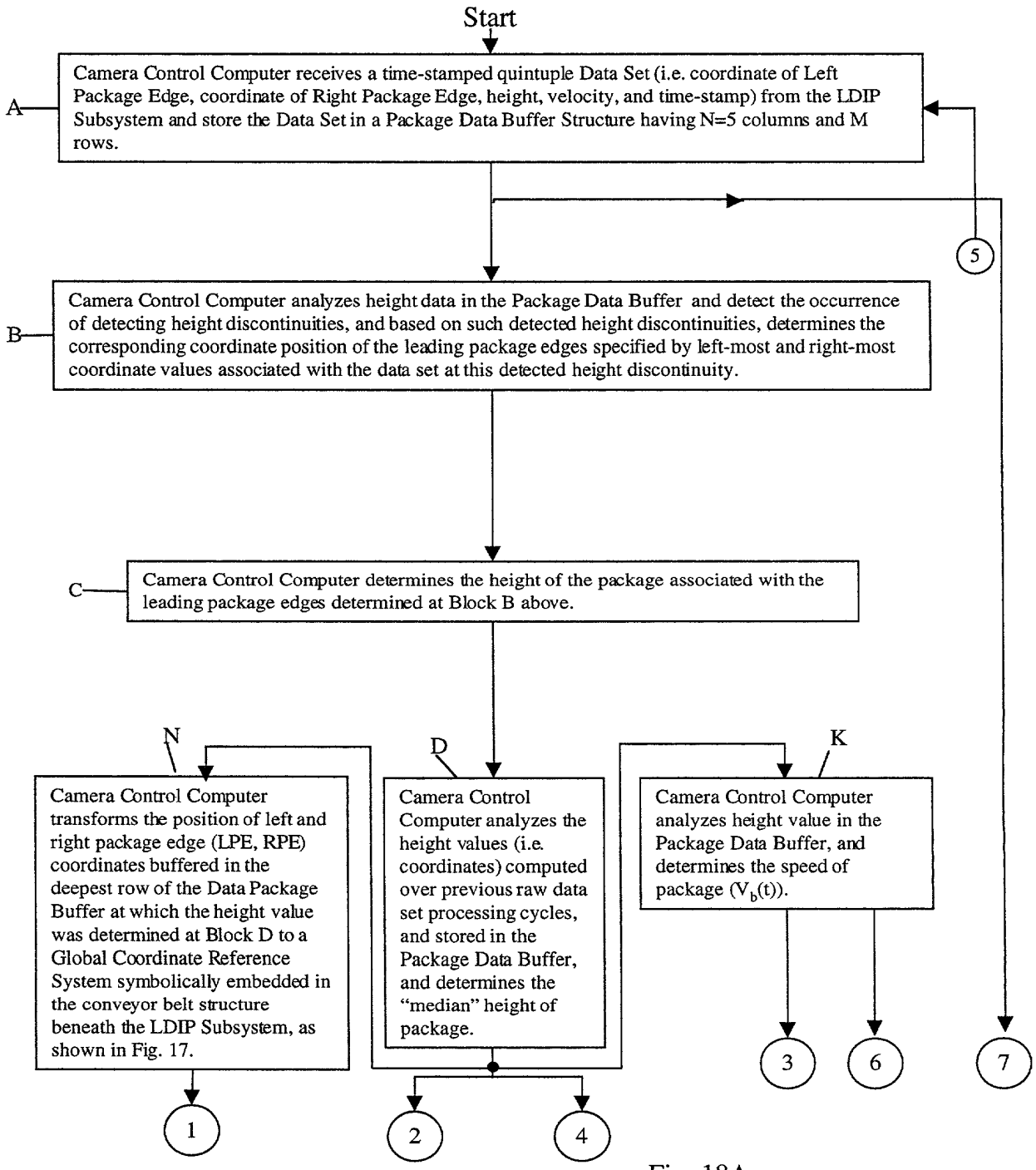


Fig. 18A

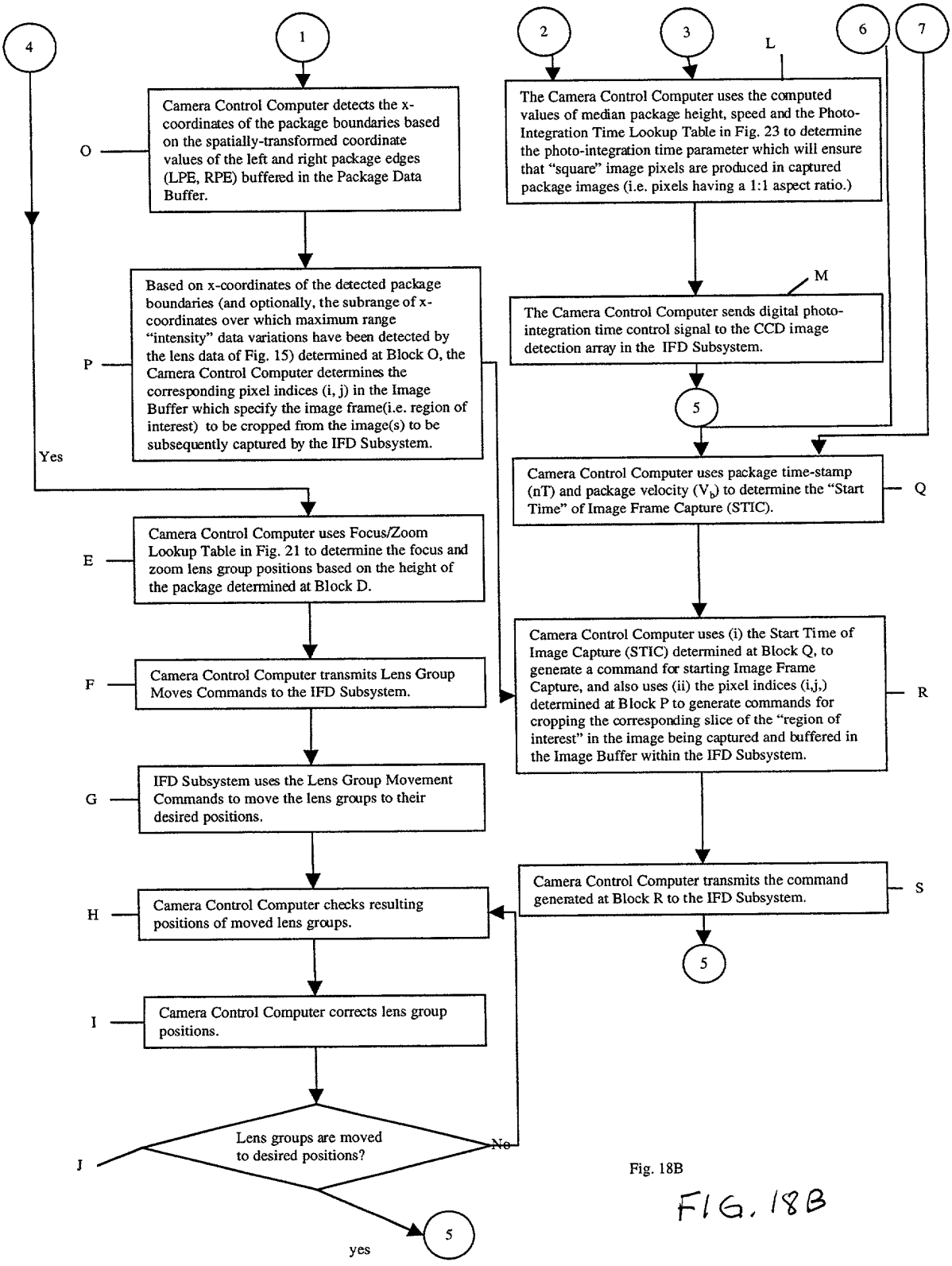


Fig. 18B

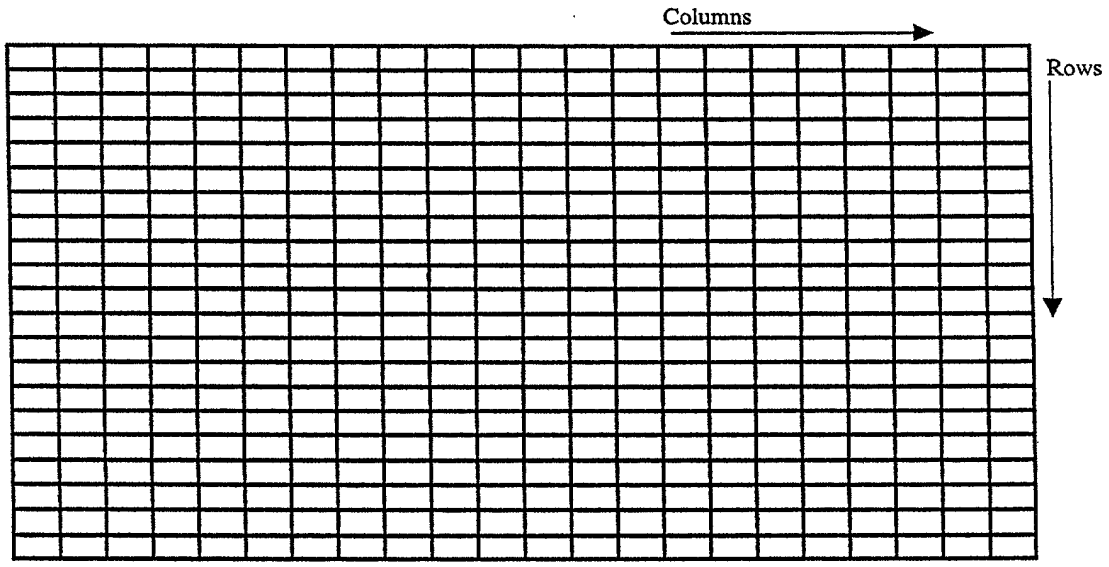
FIG. 18B

x coordinate subrange where maximum range "intensity" variations have been detected

Left Package Edge (LDE)	Package Height (h)	Right Package Edge (RPE)	Package Velocity	Time-stamp (nT)	
					Row 1
					Row 2
					Row 3
					Row 4
					Row 5
					Row M

Package Data Buffer (FIFO)

Fig. 19



Camera Pixel Data Buffer
pixel indices (i,j,)

Fig. 20

Zoom and Focus Lens Group position
Look-up TABLE

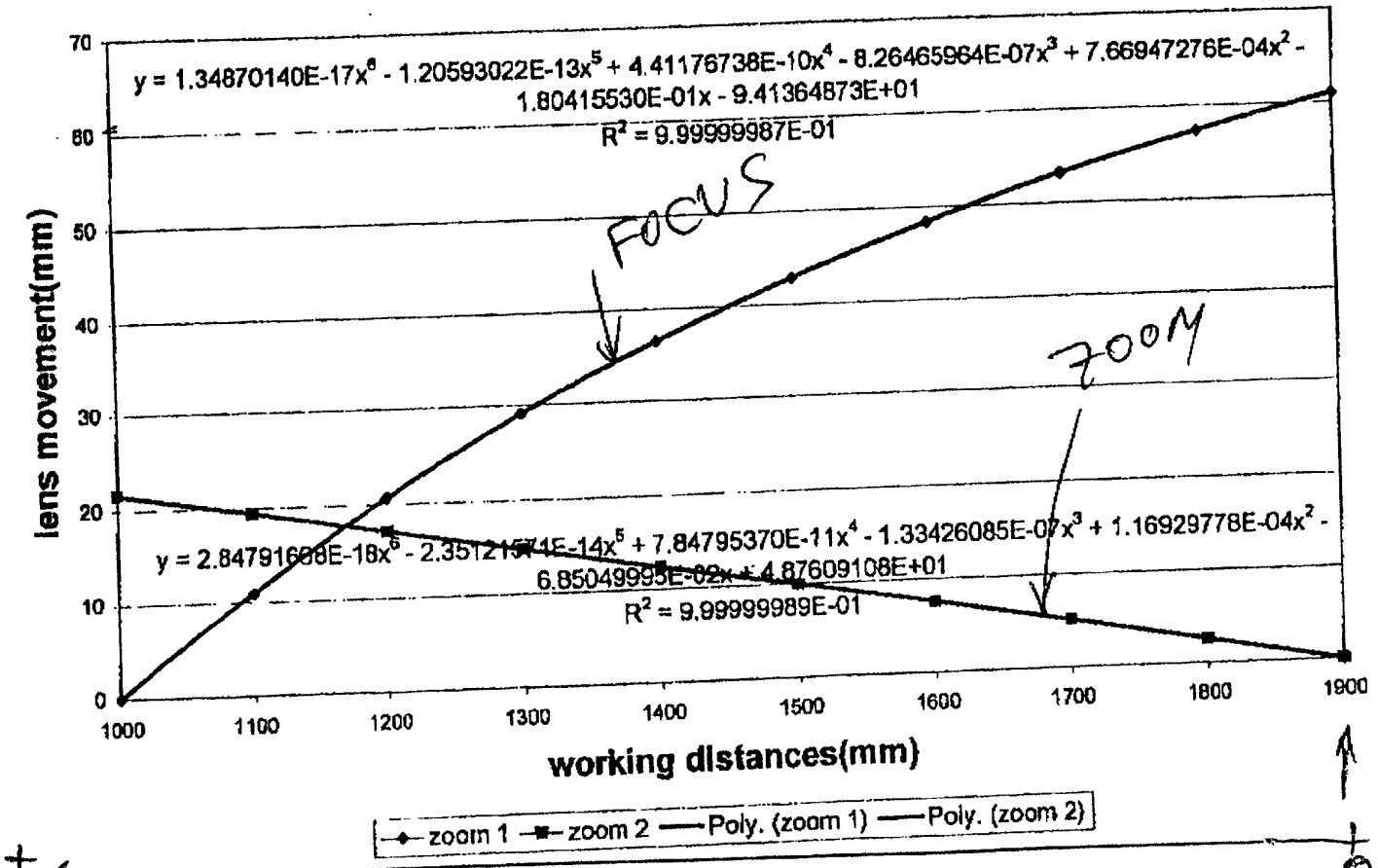
Distance from Camera H (mm)	Zoom group distance (mm) Y (Zoom)	Focus group distance (mm) Y (Focus)
1000	21.57489228	2.47E-05
1100	19.38089696	10.99009783
1200	17.10673434	20.65783177
1300	14.77137314	29.10917002
1400	12.39153565	36.47312595
1500	9.979114358	42.87845436
1600	7.540639114	48.44003358
1700	5.078794775	53.25495831
1800	2.595989366	57.40834303
1900	0.099972739	60.98883615

(use interpolation techniques for working distances between listed points in table)

FIG. 21

* Note: the focal distance & zoom (eff. focal length) of camera lens are coupled (inter-dependent) in this commercial embodiment. Camera has a
* fixed aperture F56

Focus and Zoom **lens movement vs. working distances**



+ (inches) ↑ 36" above conveyor belt

← package height above conveyor

Conveyor-belt surface

FIG. 22

doc / 100

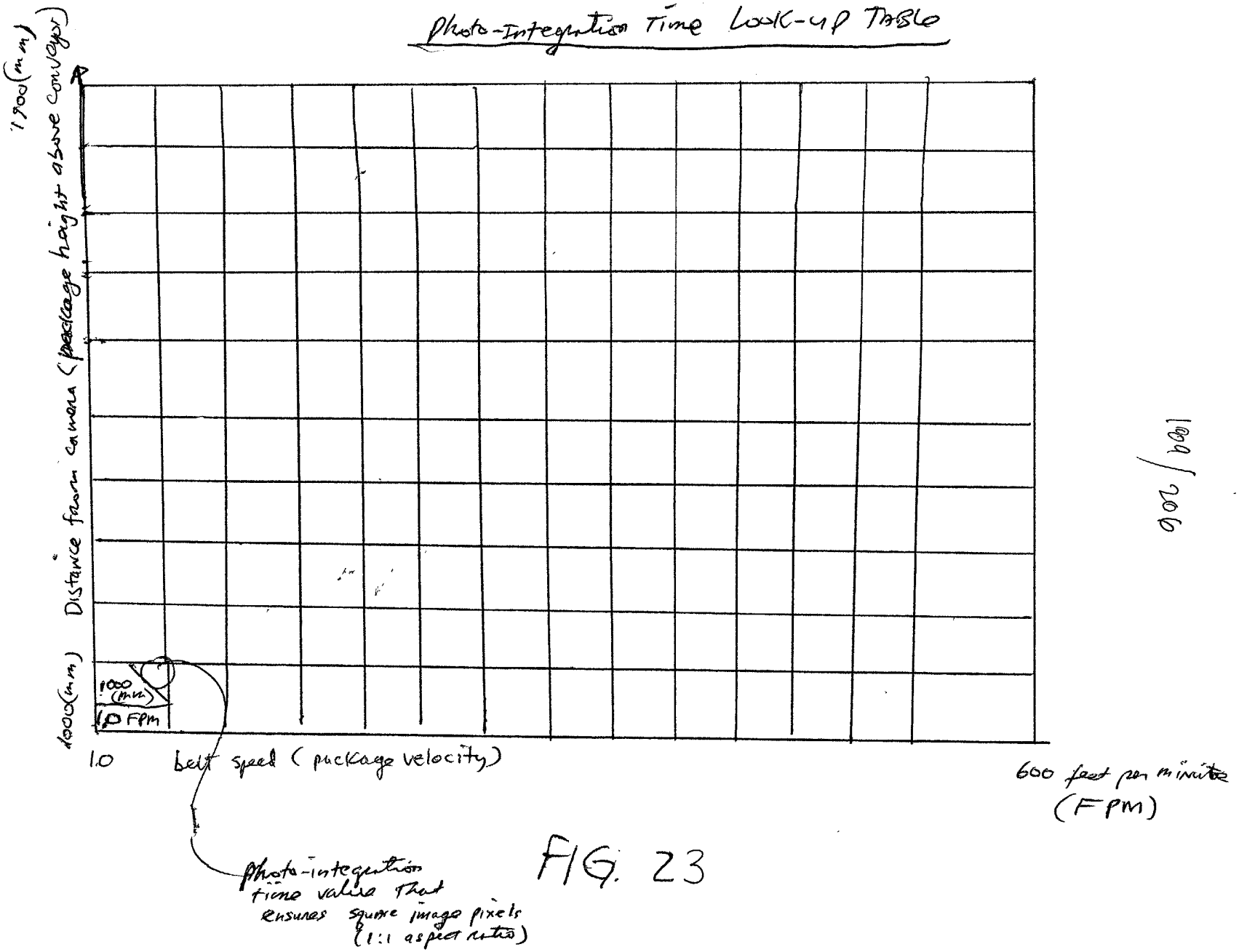


FIG. 23

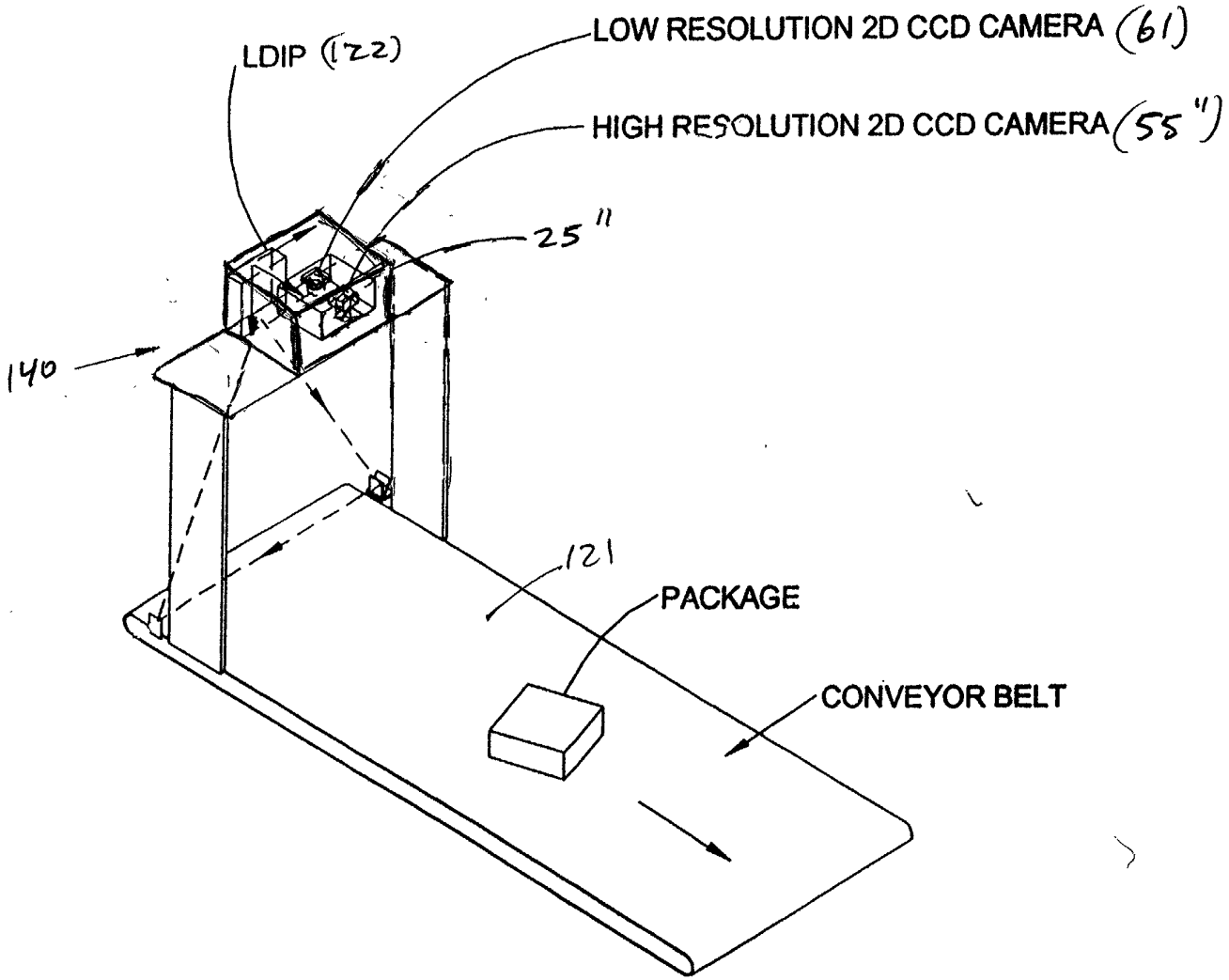


FIG 24

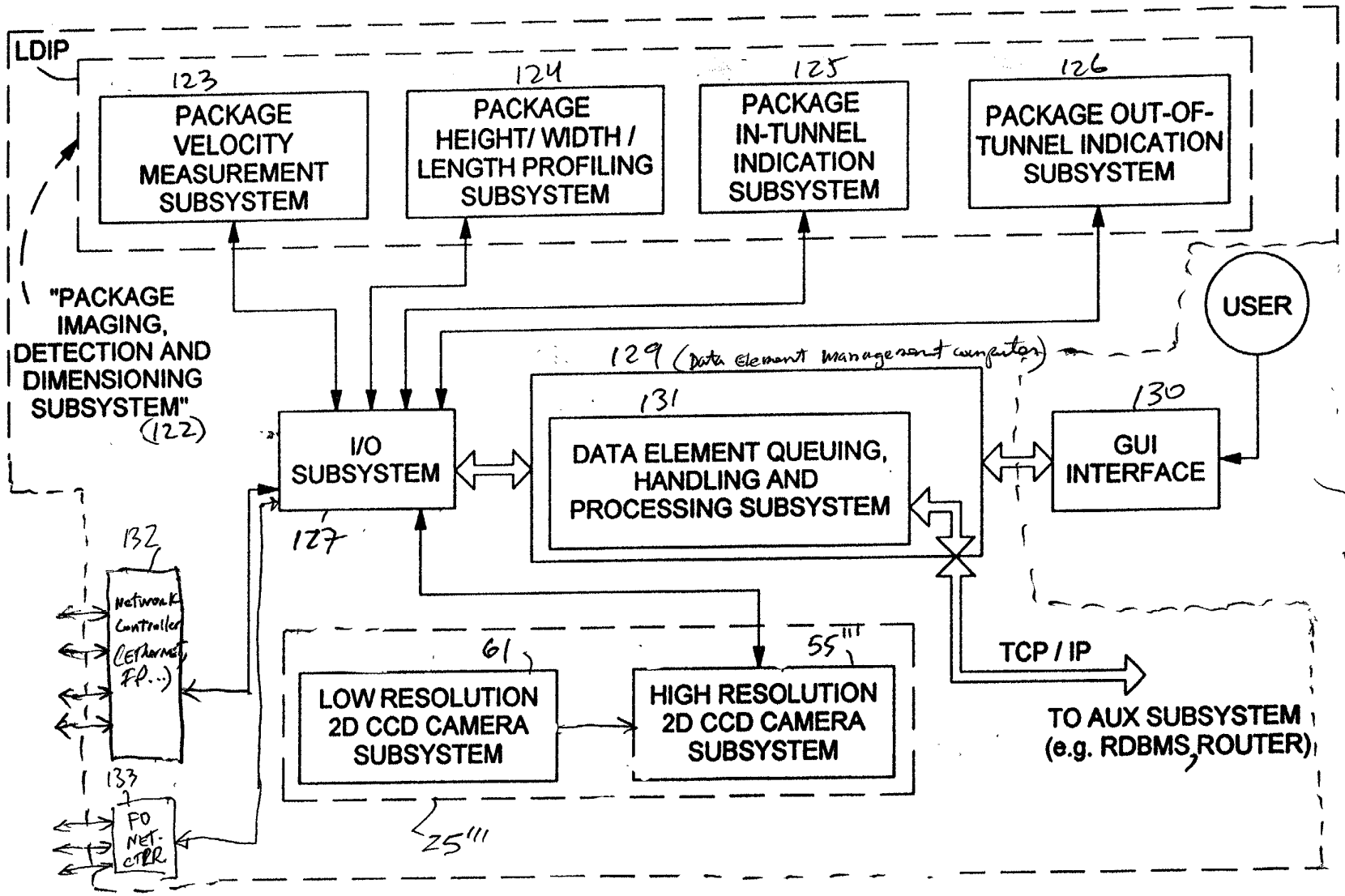
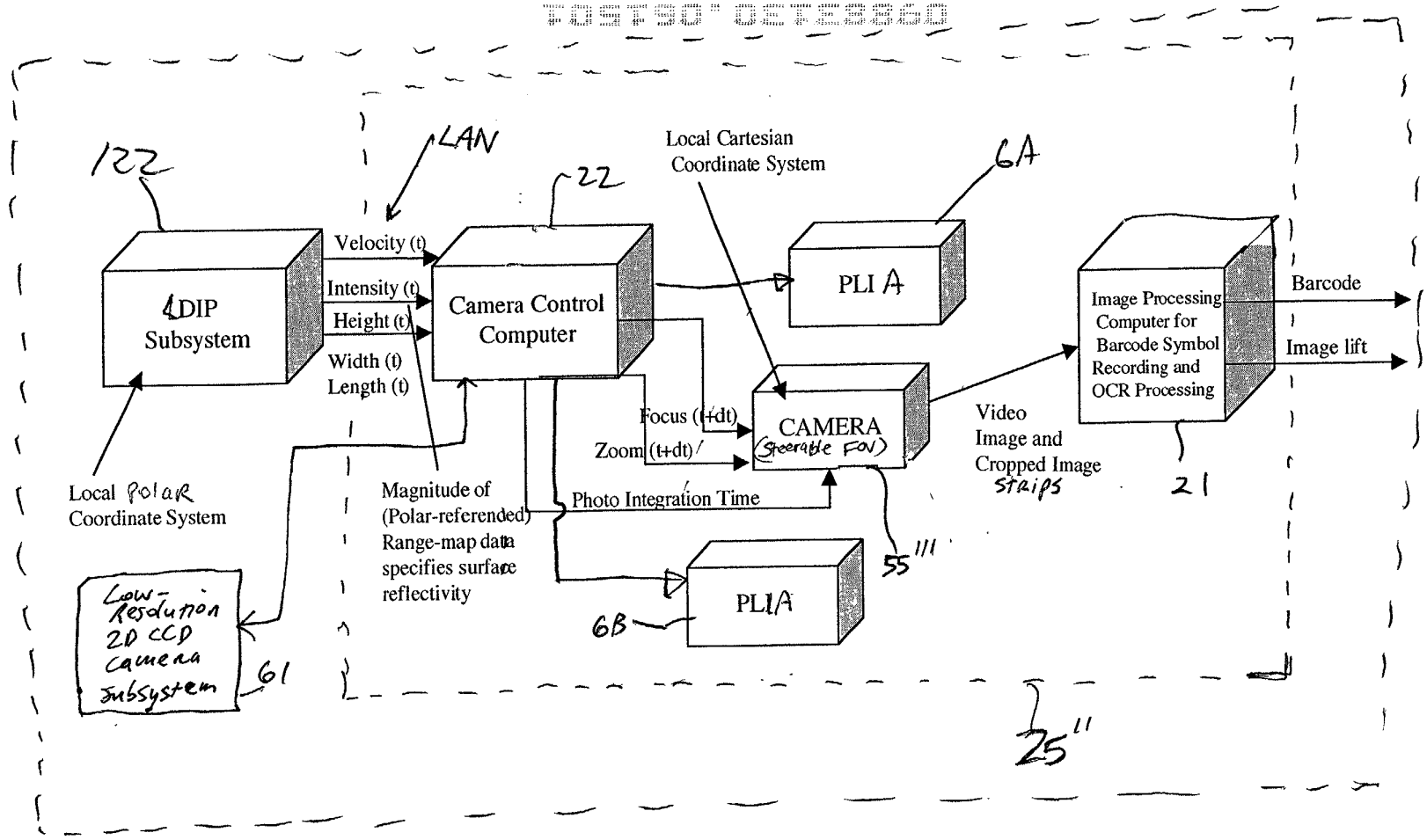

LDIP
123
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124
PACKAGE HEIGHT/ WIDTH / LENGTH PROFILING SUBSYSTEM
125
PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
126
PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
"PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM" (122)
USER
129 (Data Element Management Computer)
131
I/O SUBSYSTEM
DATA ELEMENT QUEUING, HANDLING AND PROCESSING SUBSYSTEM
130
GUI INTERFACE
127
132
Network Controller (Ethernet, FP...)
133
FO NET. CTRR.
61
LOW RESOLUTION 2D CCD CAMERA SUBSYSTEM
55'''
HIGH RESOLUTION 2D CCD CAMERA SUBSYSTEM
25'''
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)
121
206
140

FIG. 25


122
LAN
22
Local Cartesian Coordinate System
6A
DIP Subsystem
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Camera Control Computer
PLI A
Image Processing Computer for Barcode Symbol Recording and OCR Processing
Barcode
Image lift
Focus (t+dt)
Zoom (t+dt)
CAMERA (Steerable FOV)
Video Image and Cropped Image Strips
21
Local Polar Coordinate System
Magnitude of (Polar-referended) Range-map data specifies surface reflectivity
Photo Integration Time
55'''
Low-Resolution 2D CCD Camera Subsystem
61
PLIA
6B
25''
192.206
FIG. 26
140

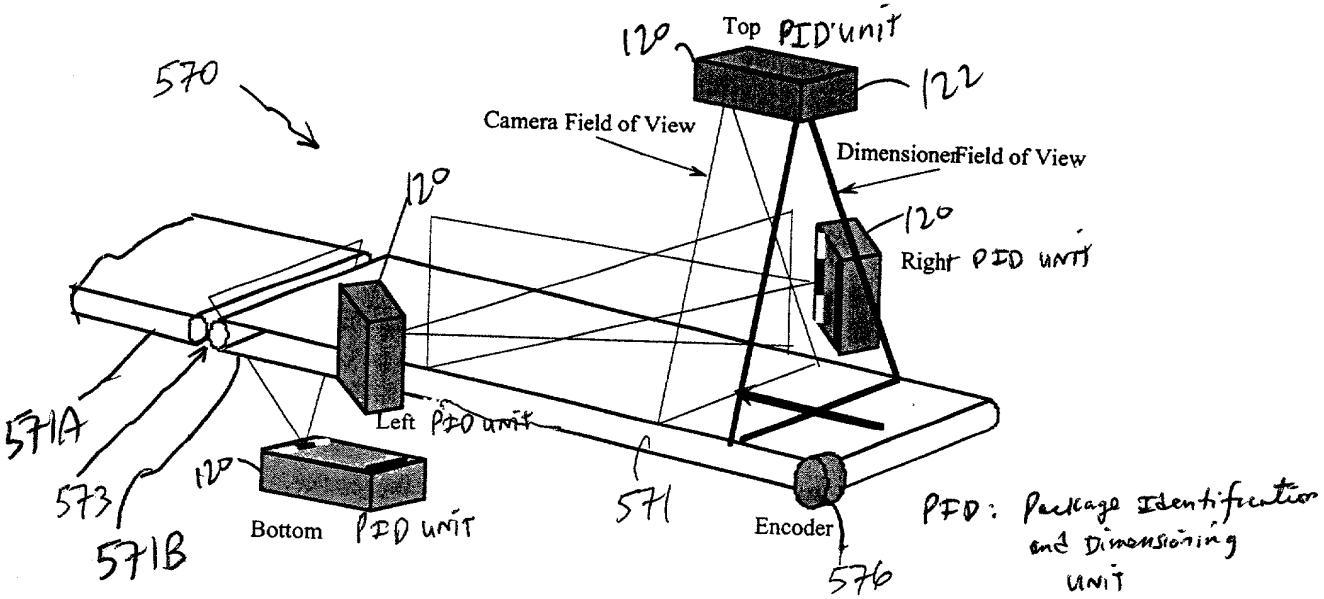

570
120
Top PID unit
122
Camera Field of View
Dimensioner Field of View
120
Right PID UNIT
120
Left PID unit
571A
573
571B
120
Bottom PID UNIT
571
Encoder
576
PID: Package Identification and Dimensioning UNIT

FIG. 27

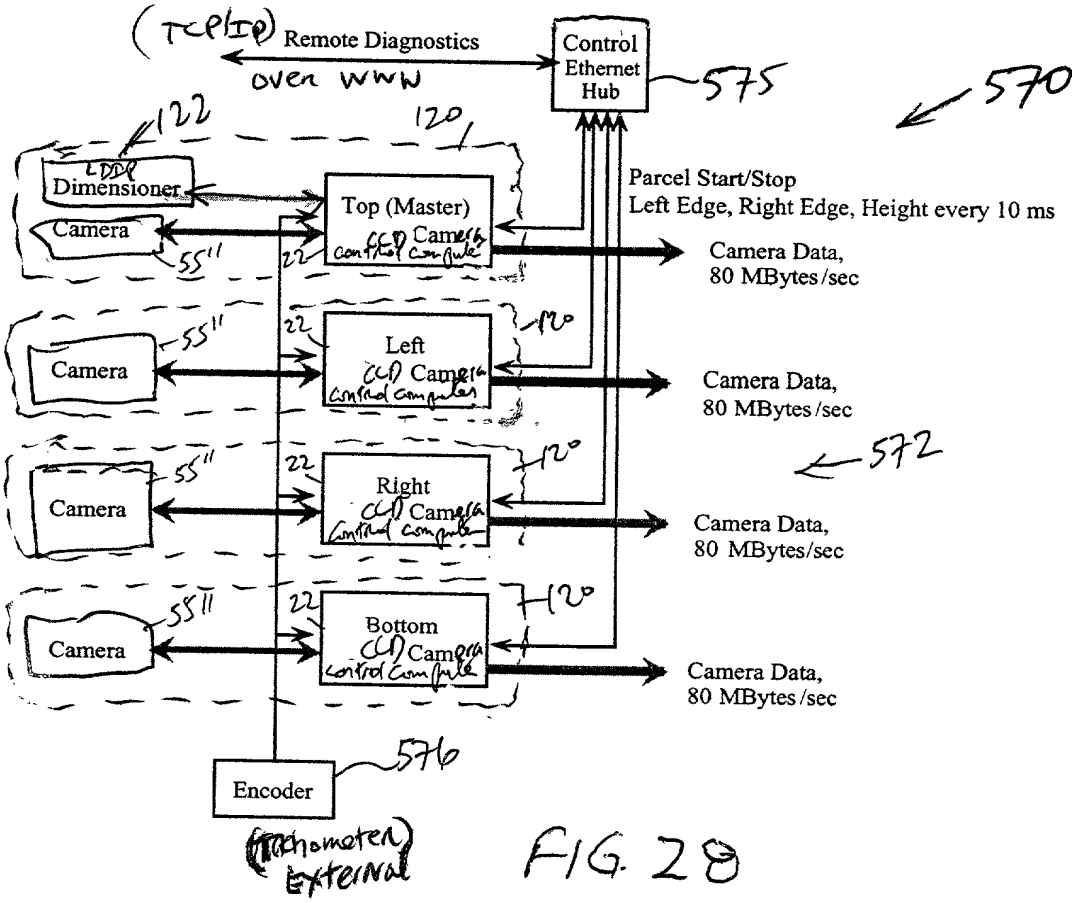

(TCP/IP) Remote Diagnostics over WWW
Control Ethernet Hub
575
570
122
120
LDDR Dimensioner
Camera
55"
Top (Master) CCD Camera control computer
22
Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms
Camera Data, 80 MBytes/sec
Left CCD Camera control computer
Right CCD Camera control computer
Bottom CCD Camera control computer
572
576
Encoder
(Tachometer External)

FIG. 28

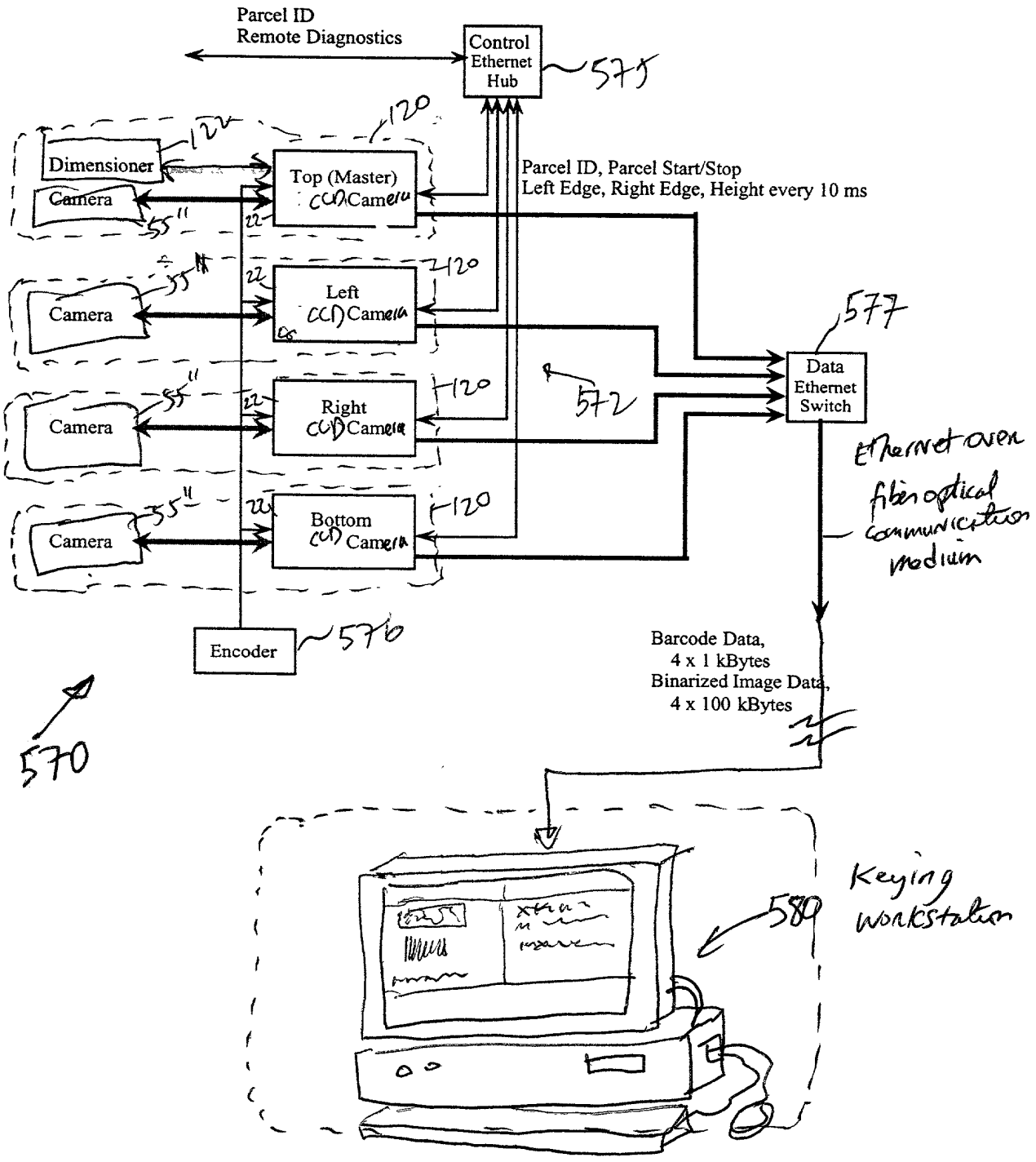

Parcel ID
Remote Diagnostics
Control Ethernet Hub
575
120
Dimensioner
Camera
Top (Master) CCD Camera
Parcel ID, Parcel Start/Stop
Left Edge, Right Edge, Height every 10 ms
55"
22
Camera
Left CCD Camera
Camera
Right CCD Camera
Camera
Bottom CCD Camera
577
572
Data Ethernet Switch
Ethernet over fiber optical communication medium
Encoder
576
570
Barcode Data,
4 x 1 kBytes
Binarized Image Data,
4 x 100 kBytes
580
Keying Workstation

FIG. 29

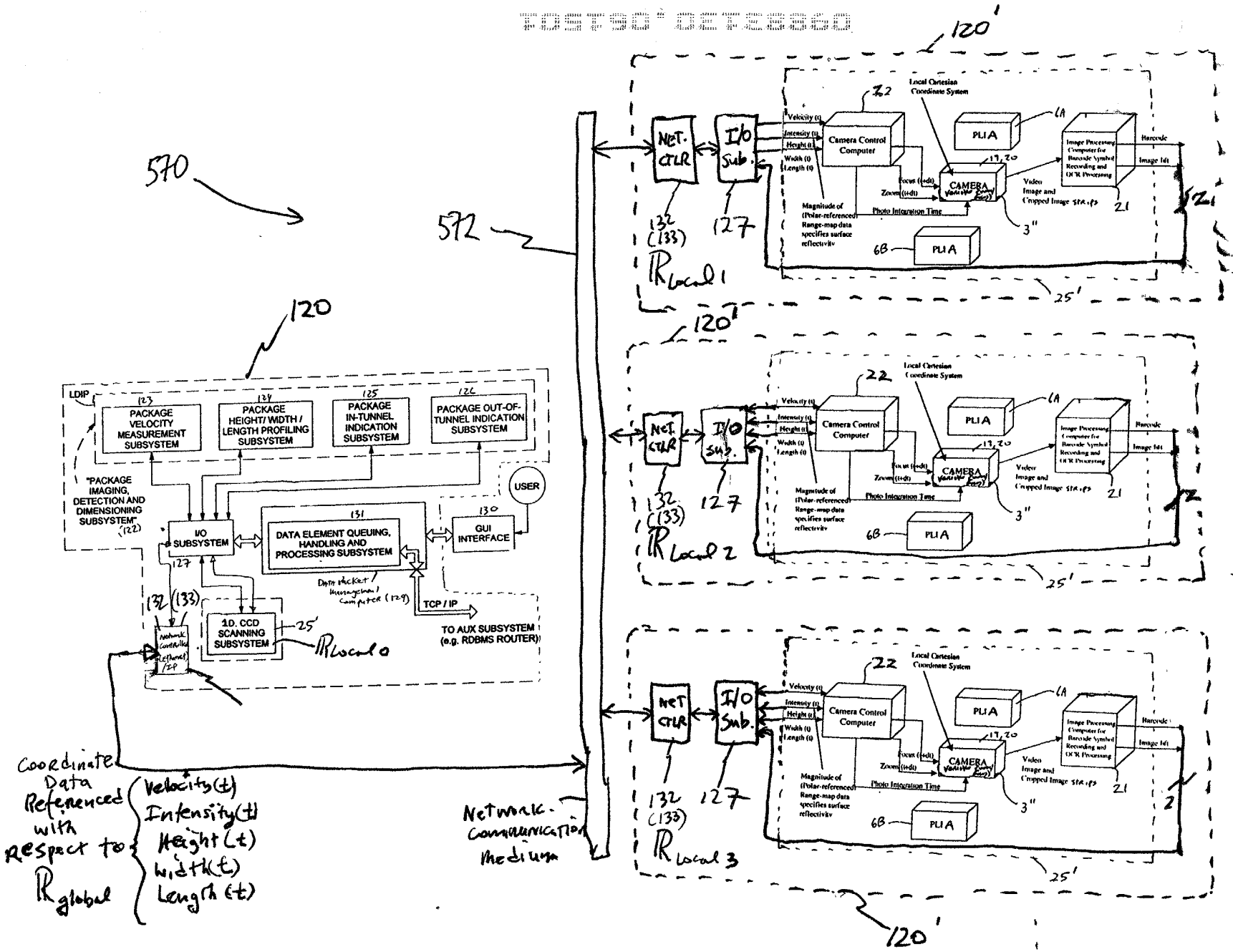
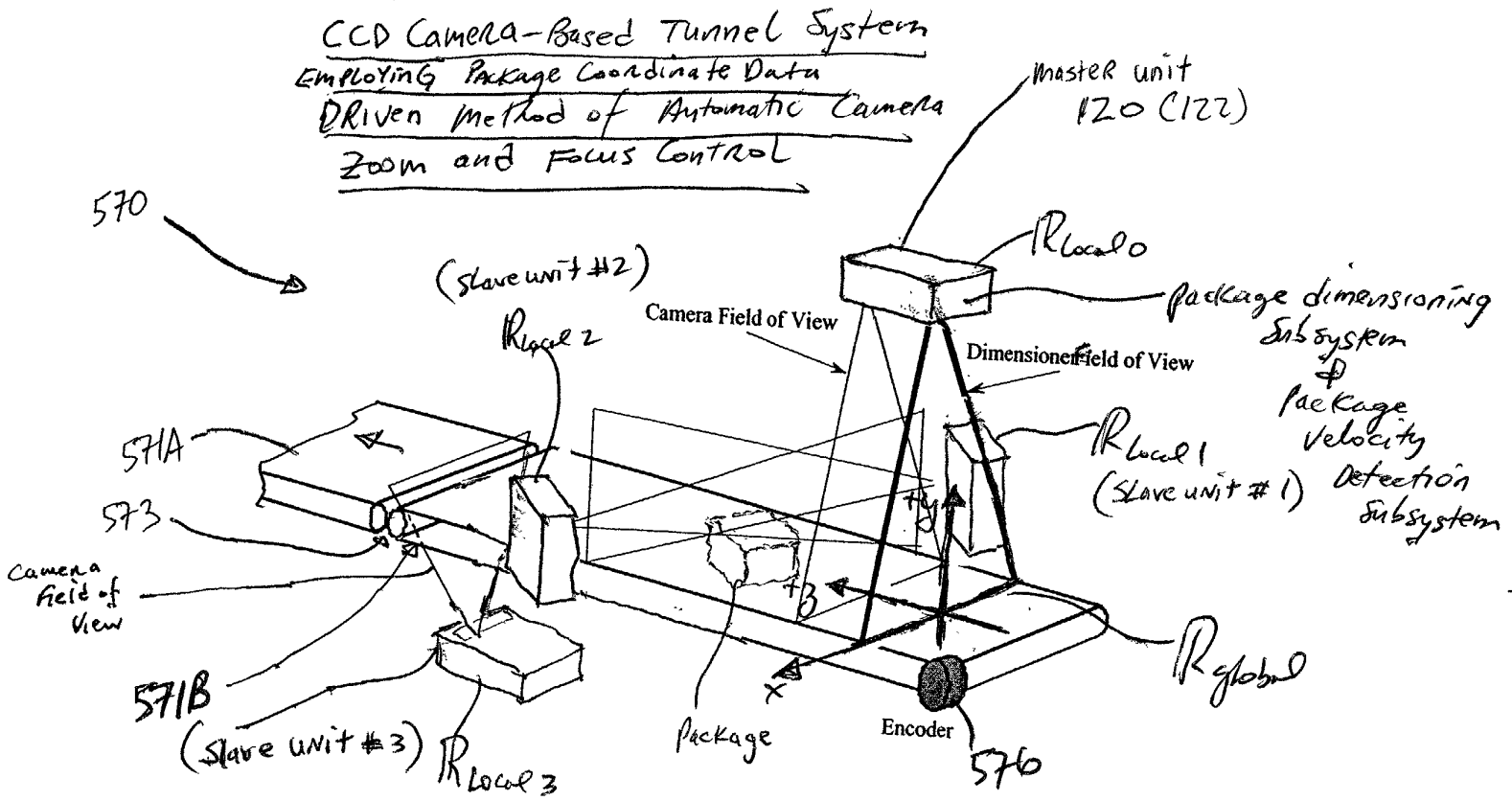


FIG 30

105/206



Package coordinate data $\|_{R_{global}}$ $\xrightarrow{HG}$ Package coordinate data $\|_{R_{local\,i}}$

FIG. 31

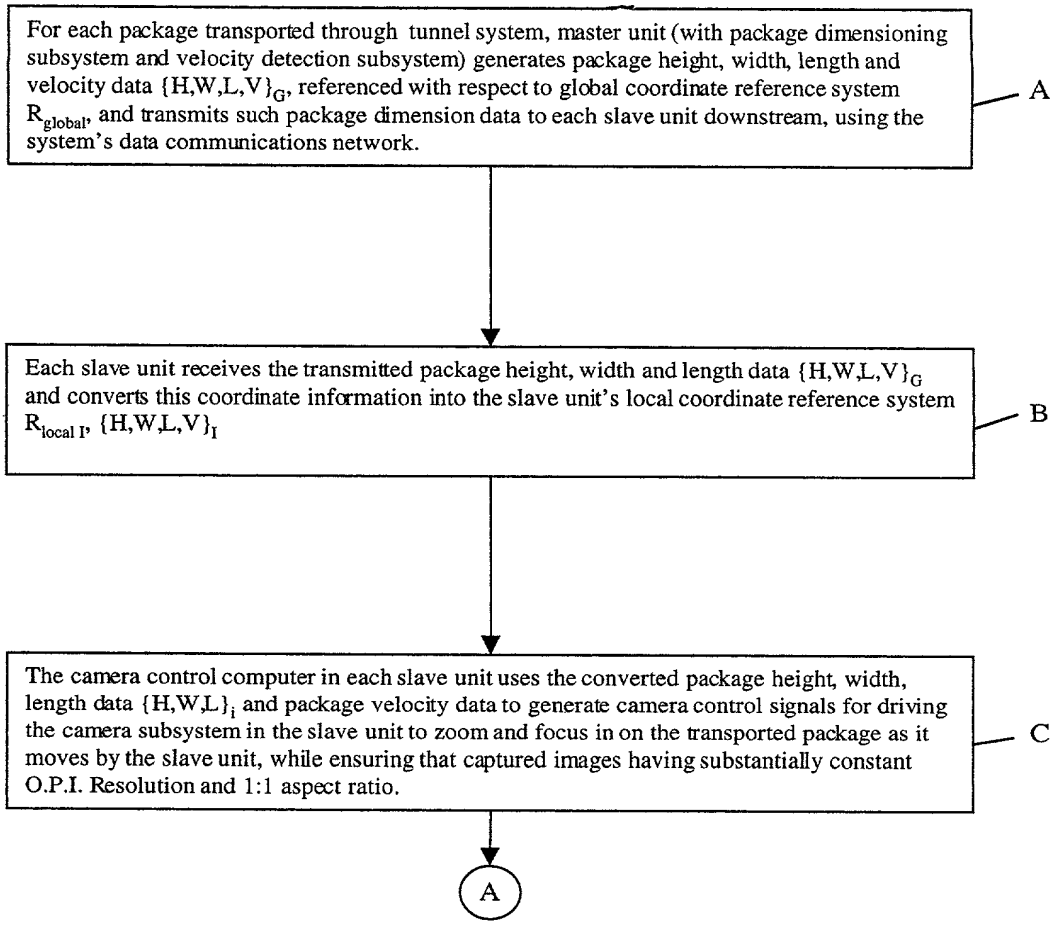

For each package transported through tunnel system, master unit (with package dimensioning subsystem and velocity detection subsystem) generates package height, width, length and velocity data $\{H,W,L,V\}_G$, referenced with respect to global coordinate reference system R_{global}, and transmits such package dimension data to each slave unit downstream, using the system's data communications network.
A
Each slave unit receives the transmitted package height, width and length data $\{H,W,L,V\}_G$ and converts this coordinate information into the slave unit's local coordinate reference system $R_{local\ I}$, $\{H,W,L,V\}_I$
B
The camera control computer in each slave unit uses the converted package height, width, length data $\{H,W,L\}_i$ and package velocity data to generate camera control signals for driving the camera subsystem in the slave unit to zoom and focus in on the transported package as it moves by the slave unit, while ensuring that captured images having substantially constant O.P.I. Resolution and 1:1 aspect ratio.
C
A

FIG. 32A

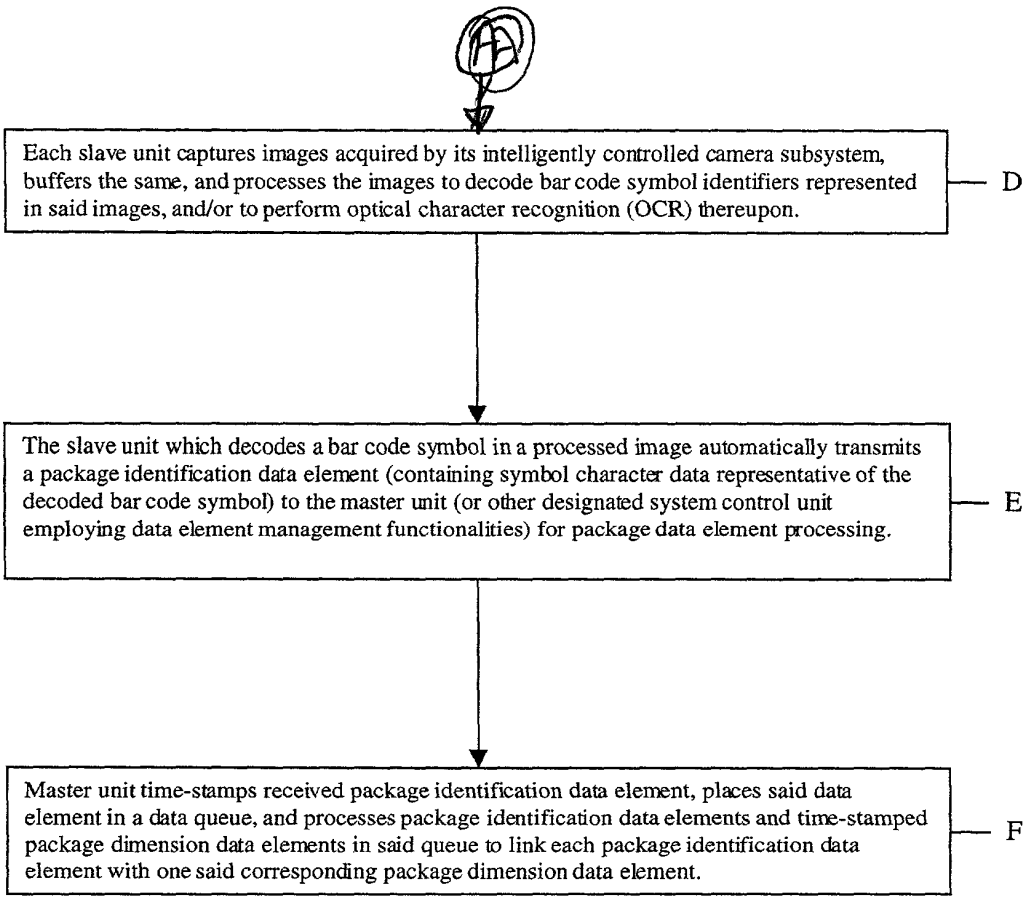

A
Each slave unit captures images acquired by its intelligently controlled camera subsystem, buffers the same, and processes the images to decode bar code symbol identifiers represented in said images, and/or to perform optical character recognition (OCR) thereupon.
D
The slave unit which decodes a bar code symbol in a processed image automatically transmits a package identification data element (containing symbol character data representative of the decoded bar code symbol) to the master unit (or other designated system control unit employing data element management functionalities) for package data element processing.
E
Master unit time-stamps received package identification data element, places said data element in a data queue, and processes package identification data elements and time-stamped package dimension data elements in said queue to link each package identification data element with one said corresponding package dimension data element.
F

FIG. 32B

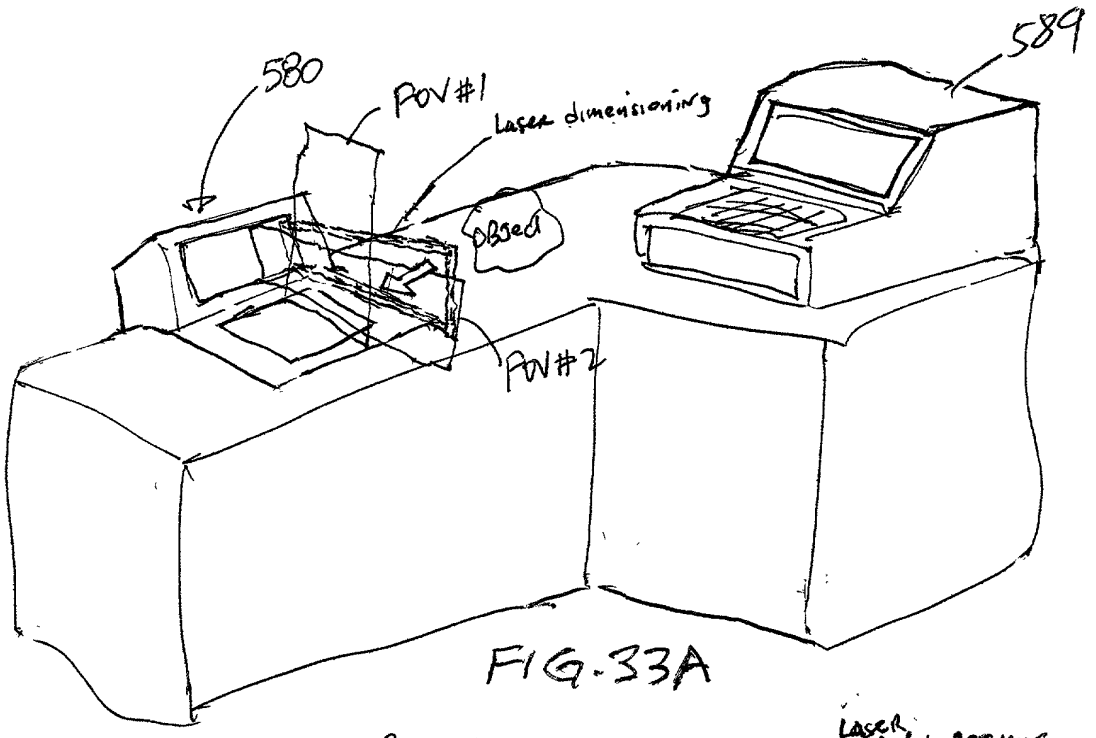


FIG. 33A

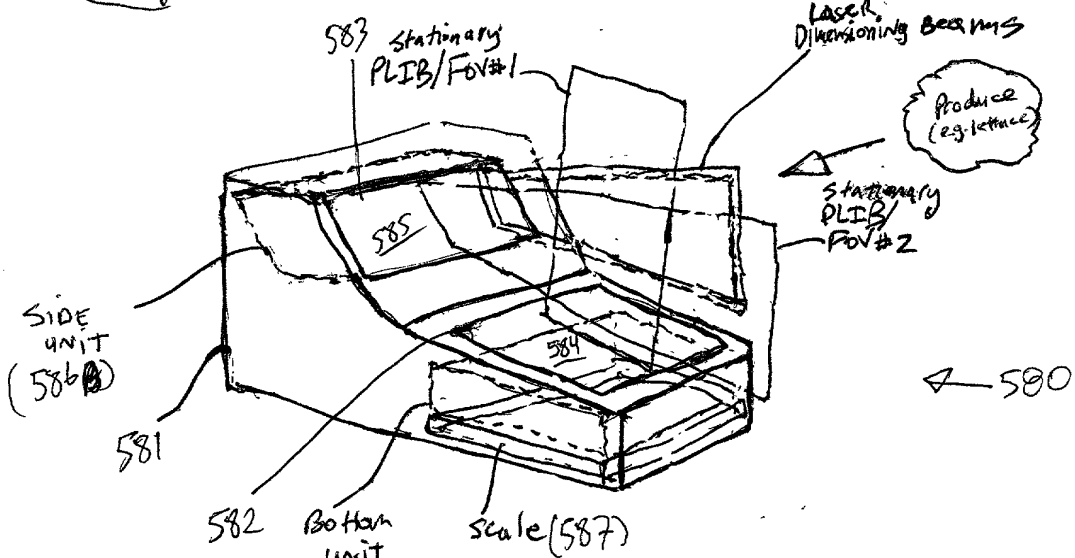


FIG. 33B

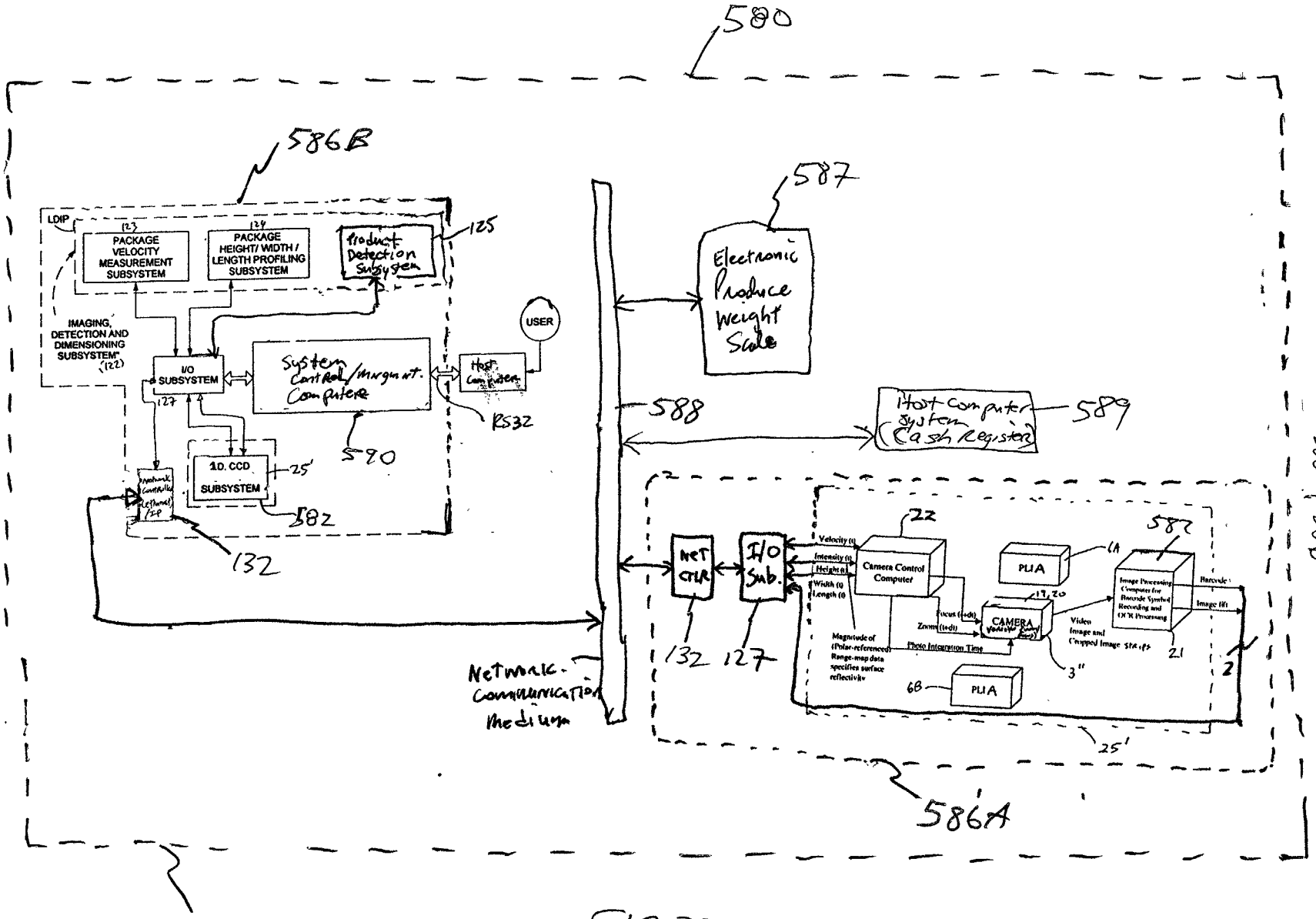


FIG. 33C

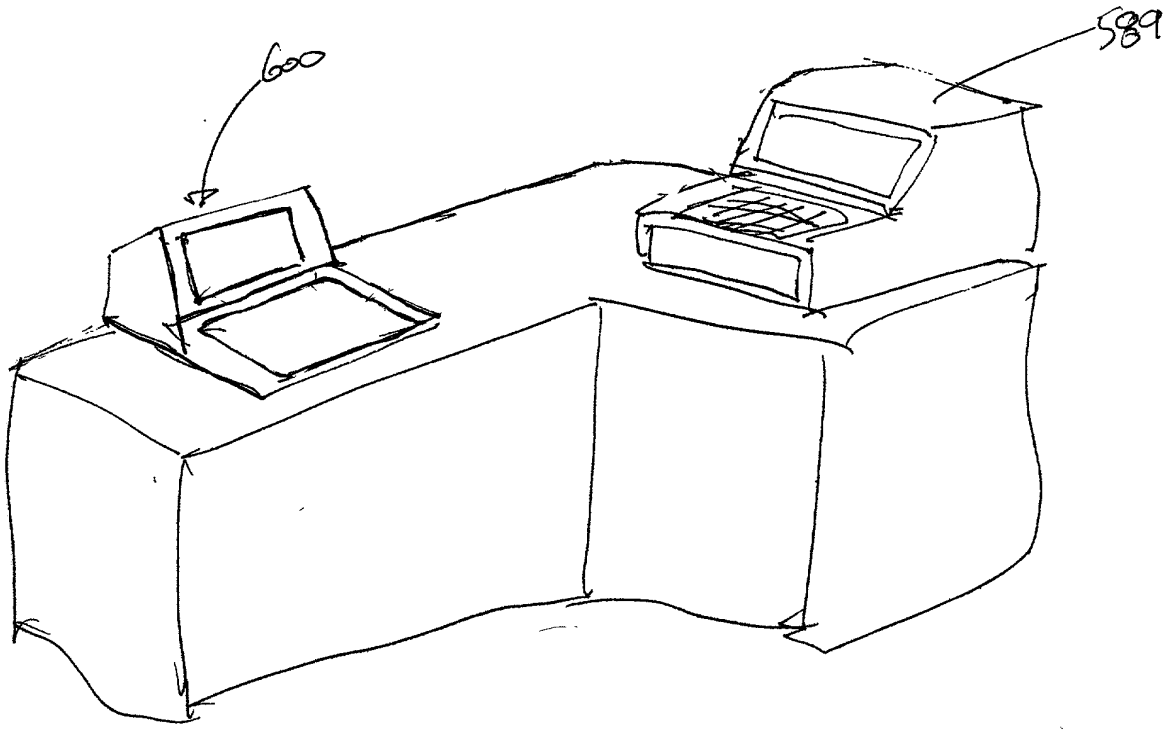


FIG. 34A

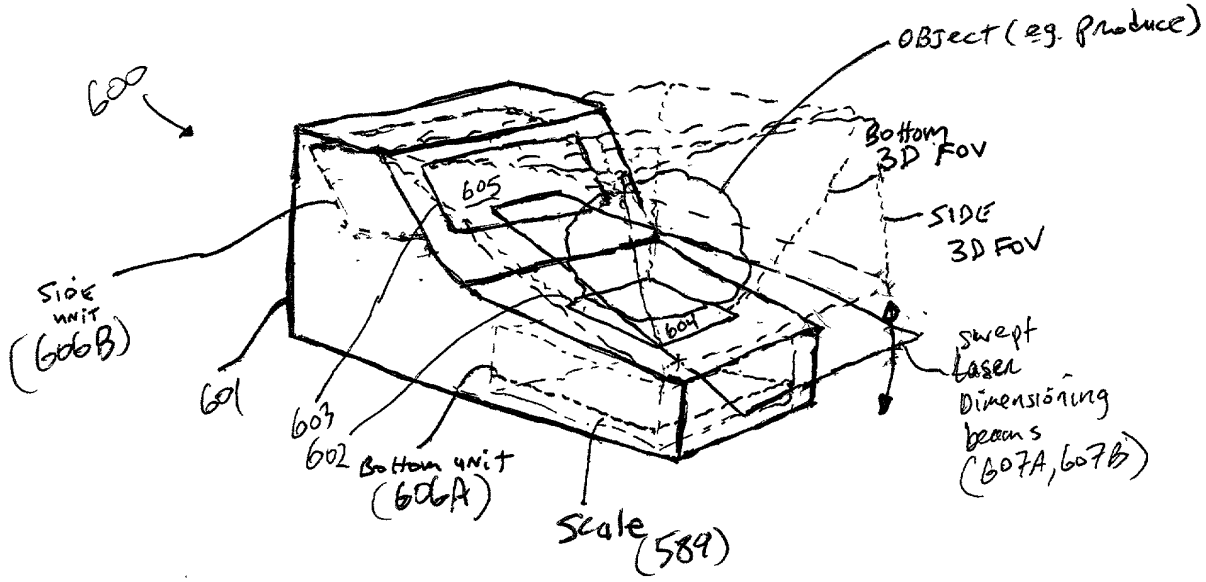


FIG. 34B

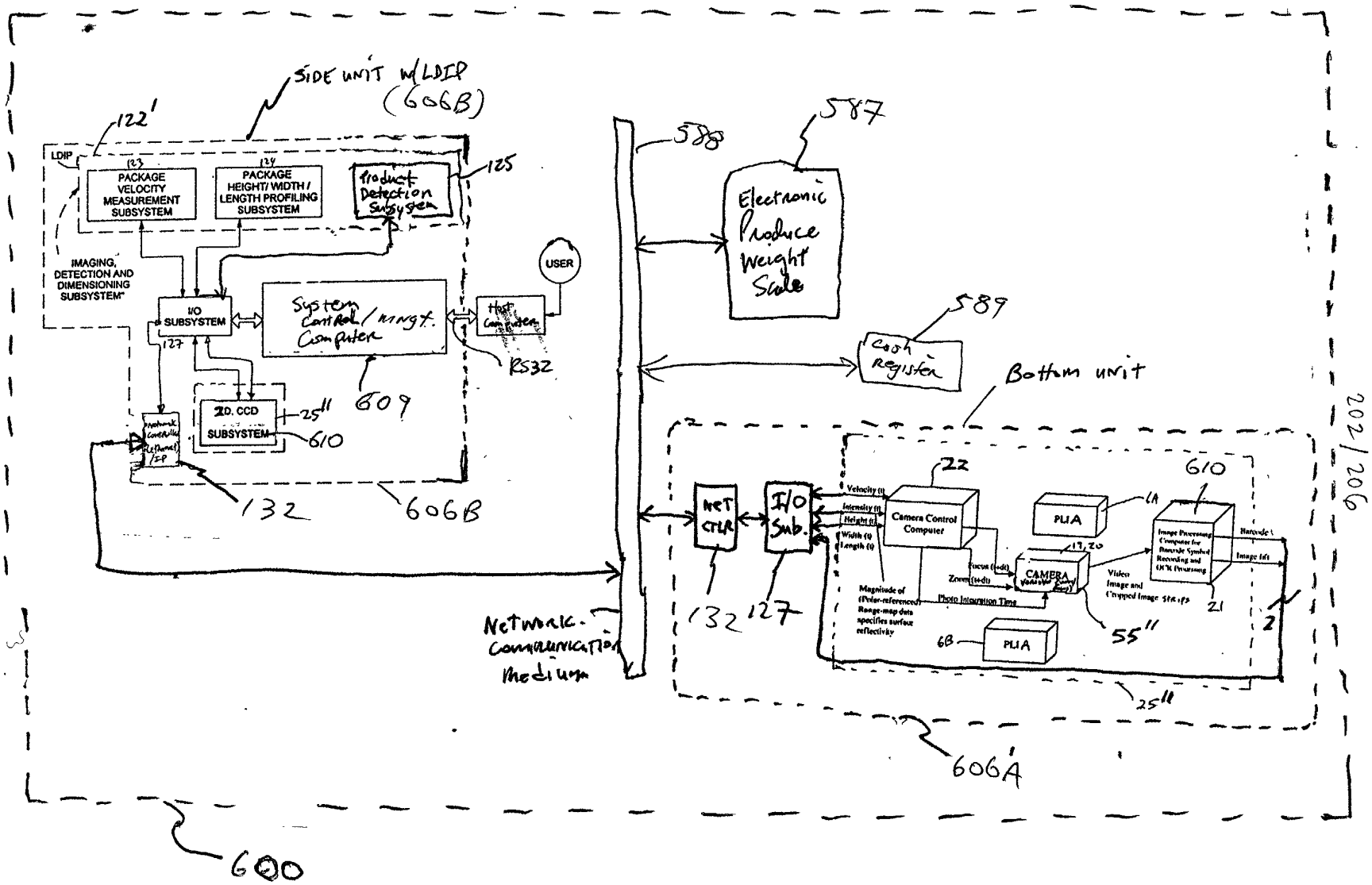


FIG. 34C

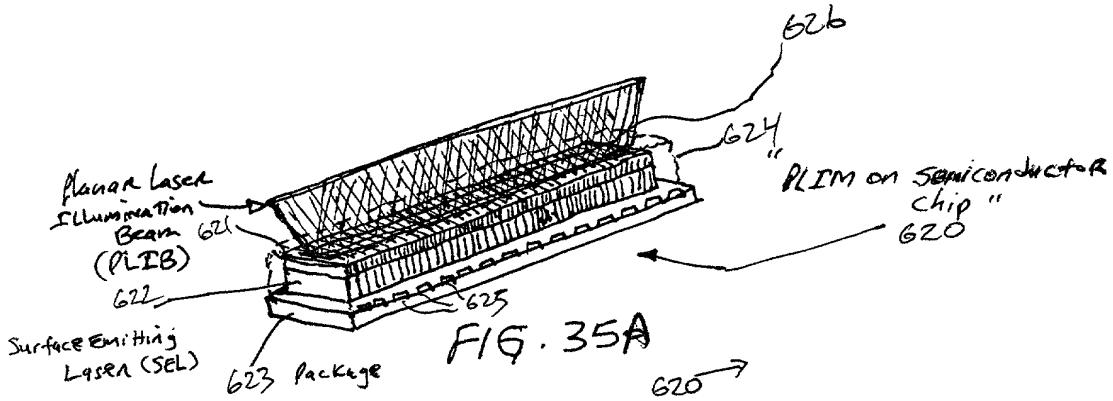


FIG. 35A

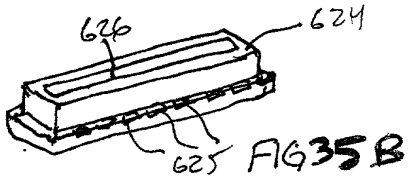
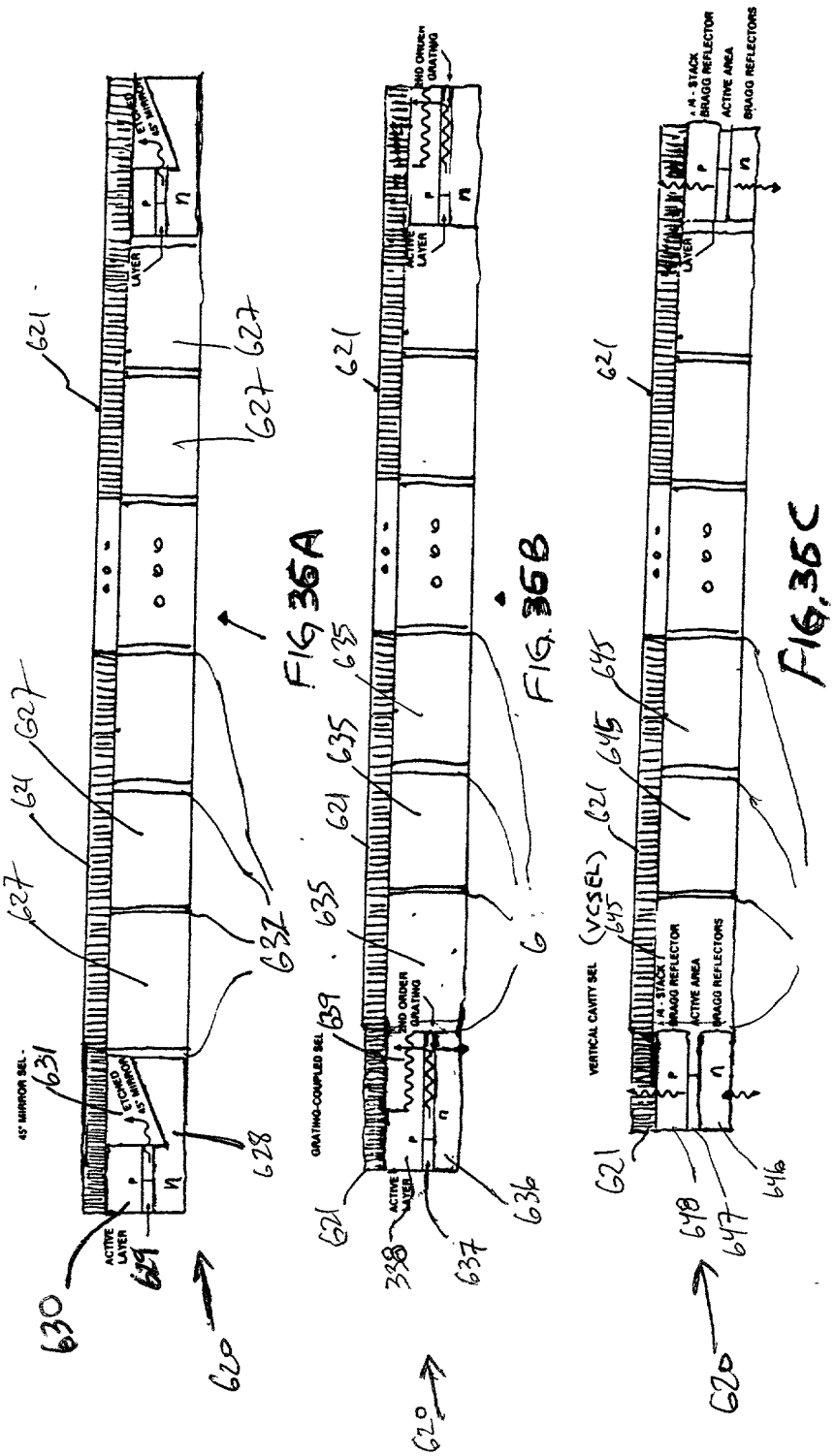


FIG35B


45° MIRROR SEL.
ETCHED 45° MIRROR
ACTIVE LAYER
n
p
621
627
624
631
628
630
620
632
FIG. 36A
GRATING-COUPLED SEL.
2ND ORDER GRATING
639
635
638
637
636
FIG. 36B
VERTICAL CAVITY SEL (VCSEL)
645
646
647
648
n - STACK BRAGG REFLECTOR
ACTIVE AREA
BRAGG REFLECTORS
FIG. 36C

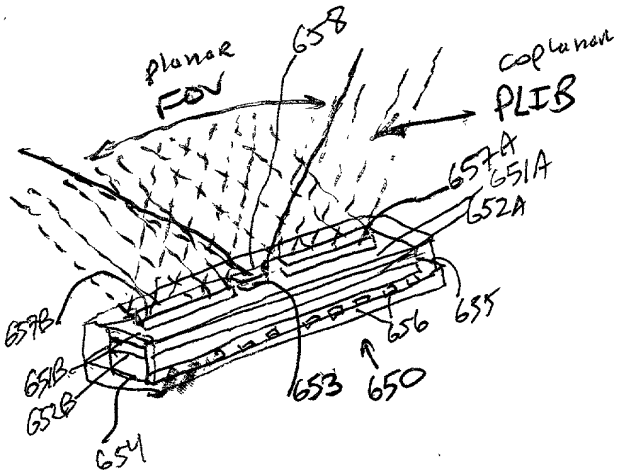

planar
FOV
658
coplanar
PLIB
657A
651A
652A
657B
651B
652B
654
653
650
656
655

FIG. 37

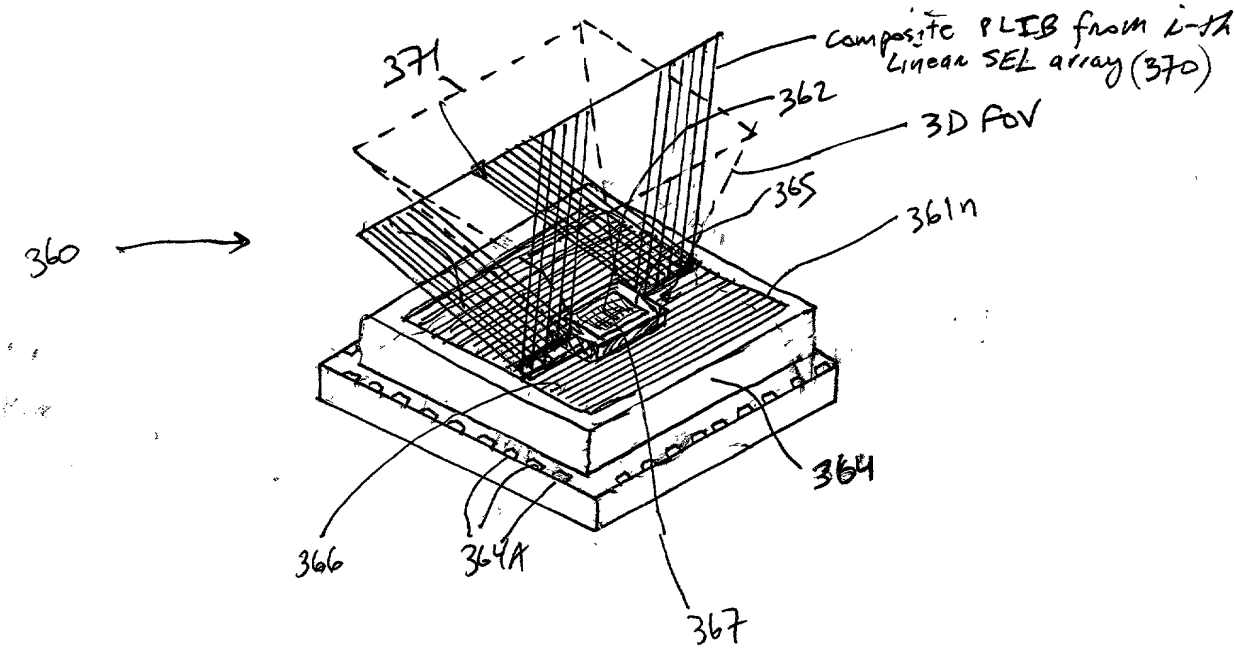


FIG. 38A

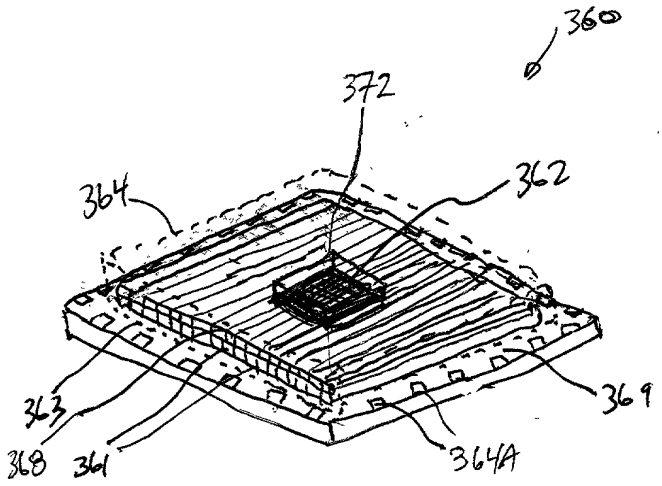


FIG. 38B